MÜLLER-BBM

Analysis and design of local air quality measurements

Towards European Air Quality Health Effect Monitoring

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Final Report

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1 Summary

Within the project presented here information has been gathered and analysed in order to

- describe the current practice of ambient air quality monitoring and its limitations in light of health relevance
- identify limitations and need for improvements with regard to air pollution health assessments
- formulate recommendations for future routine air quality monitoring as well as health data acquisition and processing
- identify areas of research needs to further substantiate the evaluation of health impact assessments

Following, the main results are summarised for these four key areas:

With respect to ***current air quality monitoring*** the requirements set by the EU directives were analysed as well as the annual reports by the Member States together with supplemental data taken from Airbase. Key results from these evaluations are

- ➔ Currently measured air quality parameters in routine monitoring were identified to be adequate in general. An extension to finer particles (e.g. PM2.5) and maybe an indicator for combustion sources (soot) is recommendable.
- ➔ The air quality assessment zones are delineated according to the administrative structure (good for action plans and measures), but zones can be inhomogeneous with regard to exposure levels.
- ➔ A comparison of population density data with zone classification as agglomeration/non-agglomeration indicates different classification approaches between the Member States
- ➔ Analyses of the site type structures (e. g. ratio background / hot-spots) within the different Member States reveals considerable variation indicating different interpretations of the directive.
- ➔ No clear documentation of the siting for the determination of ambient air quality within a zone could be identified (but is likely to exist to variable extent at Member State or EU level).
- ➔ Considerable differences of the organizational structure of monitoring networks in the different Member States were identified in the Airbase meta information.
- ➔ Insufficient information on representativeness of measurement sites related to area or population is provided by the Member States despite Airbase requests this information
- ➔ The application of default ‘areas of representativeness’ related to the various site types leads to an insufficient coverage of area and population within the Member States, indicating that such approach is inadequate.
- ➔ While in principle exposure relevance may be considered by the Member States when choosing site locations no direct relation of air quality assessment according to the current EU directive and exposure of the population could generally be identified.

From the findings described before the following main conclusions can be drawn:

- Only minor additions to the air quality components to be measured are needed.
- Accuracy, uncertainty and time resolution of air quality measurements as required by the current EU directives are sufficient compared to uncertainties for the spatial and temporal representativeness of measurements and/or model results.
- Implementation of air quality measurement requirements should partially be improved (e.g. correction factor PM) and must be a matter of continuous effort.
- The requirements set for micrositing of measurement stations are adequate, but harmonised and comprehensive documentation is needed.
- The current structure used within the ambient air quality assessment should be improved for health relevant ambient air monitoring. The main target for changes in the air quality assessment is the improvement related to the population exposure and hence one of the key issues is the representativeness of measurement sites with regard to exposure. The correct assignment of the area of representativeness and coverage of all populated areas by representative measurement sites are crucial issues to evaluate population exposure.
- Air quality data reporting should enable linkage to a Geographical Information System (GIS, e.g. within the framework of INSPIRE). This will allow the production of e.g. concentration maps in a harmonized and standardised way all over the EU.

The evaluation of the impact of air pollution on human health on a European level has to consider the following aspects:

(A) Health effect assessment, which quantifies exposure-response functions between air pollution and health outcomes in a European setting

(B) Health impact assessment, which applies exposure-response functions to European populations based on population exposure and health status data.

With respect to the current status of ***health effect assessment*** the key results of the project are:

➔ Effects of ambient air quality on human health are quantified only based on research programs (on MS or Euuropean level), such as the APHEIS project. These studies use available air quality data and health data collected within selected urban areas.

➔ Current efforts include European and Member State updates of exposure-response functions of short-term health effects from time-series analyses.

➔ No routine procedure for connecting air quality assessment and health status monitoring (e.g. daily mortality) exists.

➔ Within the mentioned research programs, air pollution data is taken from existing monitoring networks and health status data is obtained through local, regional or national authorities. Due to the variability in the implementation of the air quality directive within different Member States, no uniform population exposure assessment for epidemiological studies is currently possible. Similarly, definitions of health endpoints and reporting procedures vary between Member States. As a consequence, exposure-response functions may be biased, meaning that health effects may be over- or underestimated.

➔ Health status monitoring is currently not readily available for routine health effect assessment. Usually, a time-lag of minimum one year exists for temporally high-resolved health data needed for time-series studies to investigate short-term health effects.

➔ No European wide study on long-term health effects is available or has been initiated.

➔ Systematic reviews are conducted summarizing the available exposure response-functions to provide summary estimates. These functions are used by European research projects or occasionally by member state bodies to conduct health impact assessment.

With respect to the current status of ***health impact assessment*** the key results of the project are:

➔ Research projects standardizing and applying health impact assessment methods are currently being conducted or have been completed recently.

➔ The temporal and areal resolution of the data used is often different for population exposure values and population health status data.

➔ Population health is monitored on national and regional level. Data needed for HIA, spatially high-resolved but temporally aggregated, is available as yearly averages through EUROSTAT.

Based on the above results the project concluded the following

- In contrast to air pollution monitoring it is not feasible to "monitor" health effects.
- Additional efforts would be needed to update the exposure-response functions to allow reflecting changes in air pollution composition caused by current abatement strategies.
- Additional efforts would be needed to provide estimates of the long-term health effects based on new European epidemiological studies to improve health impact assessment.
- Improved health status monitoring for morbidity would allow for more accurate and more complete health impact assessment.

Based on the analyses of the current state of air quality and air pollution health assessments a ***New Practical Approach*** has been developed which is built on three pillars:

- **routine air quality monitoring** at sites with optimised representativeness information;
  - With respect to air quality monitoring an accurate assignment of those areas and fraction of population which are represented by the monitoring sites is considered to be of paramount importance. To achieve this, it is proposed to develop a methodology which uses complex chemistry transport models and sophisticated statistical tools for identifying and clustering comparable areas with a resolution of at least 5*5 km². Additionally, modelling with higher resolution shall be performed to identify industrial and traffic hot-spot areas.
  - Population exposure should be assessed using information on the population density and, wherever possible, on the time people spent in different exposure situations.
  - This work and the obtained data should enable a linkage to other GIS-data such as population density, emission inventories etc.
- **routine health status monitoring** in selected regions of the Member States connected to routine short term health effect assessment;
- **selected "superregions" in Europe** to complement these two routine components by extended research activities related to air quality being linked to exposure, epidemiology and toxicology
  - The monitoring network in the superregions should comprise regions with significant exposure differences, however both being located in the same climatic and meteorological background.

  - Within the superregions both a more extensive air quality monitoring including additionally compounds (e.g. for source apportionment purposes) and long-term/short-term epidemiologic studies should be carried out to gather new data on health effects and to improve the exposure response functions.
  - Toxicological studies should be linked to these regions in order to e.g. identify the health relevant compounds in particulate matter.

- health impact assessment integrating all three pillars

These key elements together would provide the data necessary for improved health effect and health impact assessment in Europe.

2 Introduction and task

This report summarises the results of a project of the European Commission asking for services related to the Clean Air for Europe (CAFÉ) programme. Background of the tasks as described in this call is the ongoing activities of the European Commission on the implementation of the thematic strategy on air pollution which was communicated on 21 September 2005.

This thematic strategy relies considerably on assessments of air quality and of related human health effects. Currently, air quality assessments carried out in the EU Member States appear to be not entirely comparable due to certain differences in the application and interpretation of the guidelines and regulations laid down by EU legislation. Furthermore, standardised procedures for air pollution related Exposure and Health (E&H) effect assessments have not yet been introduced.

Therefore the key issues of the project are the analyses of the current practices of air quality and E&H assessments in the 25 EU Member States aiming at recommendations for future legislative activities with regard to

- Improved inter-country comparability of air quality and E&H assessment results
- Improved air quality network design and monitoring strategy in relation to E&H relevance
- Proposal of a methodology and network design for air pollution related E&H effect data acquisition, health effect quantification, systematic review of air pollution related health effects and health impact assessment

The tasks comprise the analysis

a) of the current status related to ambient air quality monitoring and assessment (including modelling),
b) on how effects of ambient air quality on human health are currently monitored, assessed and communicated, and
c) The identification of problems in the current systems in view of their use for health effect monitoring and comparability between Member States.
d) A new practical network and monitoring design will be developed based on the prior analyses enabling a European wide comparable health effect monitoring and hence a basis for the identification of possible, cost effective improvements for different areas within Europe.

3 Definitions of terms

3.1 Air quality monitoring

Air quality monitoring comprises the methodology to gather concentration values for specified pollutants. This may be done to assess the air quality with respect to various objectives which may include compliance checking, representative air quality surveillance, exposure and damage assessments, on-line warning purposes and operational monitoring of polluting industrial plants [Larssen et al, 1999]. Depending on the objective, siting and equipment of measurement stations as well as the monitoring frequency will vary.

3.2 Air quality assessment (according to EU air quality directives)

The assessment procedures may involve measurements at one or more locations as well as the application of suitable models to infer concentration data for the targeted area of interest. Depending of the objectives for monitoring the air quality assessment may include for example the consideration of background concentration values in comparison to measured ones, the evaluation of time trends and the apportionment of various emission sources. More specifically, with respect to the EU air quality directives, the assessment of air quality is made by comparison of the concentration values gathered for a zone with the limit, target and threshold values laid down in the air quality directives. The assessment does not only comprise a check for compliance with limit or target values but also an evaluation of the air quality of the time trend seen in previous years by comparison of multi-annual averages with upper and lower threshold limits. The evaluation in turn determines e.g. the need for additional or the possibility to decrease the measurement efforts in the considered zone.

3.3 Exposure

Exposure to a pollutant is defined as “the event when a person comes into contact with a pollutant of a certain concentration during a certain period of time” (Ott, 1982). This definition distinguishes exposure from concentration on the one hand and dose on the other hand and refers to a contact with the pollutant.

3.4 Exposure assessment

Exposure assessment provides the critical link between the pollution source and human health, and is a necessary step in the risk assessment process (Moschandreas and Sachsena, 2002). Air pollution exposure assessment is defined as “the study of the distribution and determinants of air pollution”. It includes the estimation of intensity, duration and frequency of exposure, the variation in these indices, and their determinants. The exposure assessment process (regarding air pollutants) commences with an evaluation of the outdoor concentrations of the targeted pollutants. This can be done e.g. by air quality monitoring (measurements/ modelling) or by dispersion modelling starting from an identification and listing of major sources of the pollutant under investigation and associated source emission rates. The dispersion modelling ideally includes the transport and fate of the pollutants in all of the relevant environment media. The final step of the exposure assessment process is to link the estimated outdoor exposure with the sites where receptors come in contact with the agent (pollutant) and provide the link between source and ultimate health effects. Quantification of the relation between exposure and adverse human health effects requires the use of exposure estimates that are accurate, precise and biologically relevant, for the critical exposure period, and show the range of exposure levels in the population under study.

3.5 Health status monitoring

Health status monitoring in the context of the present report comprises routine recording of health endpoints relevant to air pollution health effects within defined populations on regional or national level.

Generally, temporal and spatial monitoring can be distinguished. Temporal health status monitoring is needed in epidemiological studies for short-term air pollution health effect assessment. Spatial health status monitoring is the recording of the annual health and (demographic) population parameters. For health impact assessment the distribution of the population at risk and frequency of the outcomes are needed. These data are required on the same regional level as the different air pollution categories.

For the evaluation of chronic health effects of air pollution cohort data is needed to adequately adjust for individual risk factors. A health status monitoring in cohorts is not feasible.

Health status monitoring is also needed. For air pollution health effect assessment yearly indicators of population health which may modify the association between air pollution and health outcomes are required.

3.6 Air pollution health effect monitoring

Health effect monitoring is “the performance and analysis of routine measurements of health status of the population aimed at detecting changes in the environment leading to changes in the health of populations”. In many public health investigations, it is possible to measure changes in a defined population health indicator and to attribute this trend to changes in a directly-acting environmental risk factor.

However, the health impact of air pollution in the population is small compared to the observed variation in these health status indicators. Therefore online monitoring of health effects of air pollution is judged to be impossible due to its ambiguity.

3.7 Air pollution health effect assessment

To assess the magnitude of air pollution health effects epidemiological designs and analyses are needed. Therefore air pollution health effect assessment in this report is meant synonymously with epidemiology of air pollution health effects.

Epidemiological designs to assess air pollution health effects differ depending on the time window of exposure considered (long-term effects/ short-term effects). Study designs suitable to study short-term effects are for example time-series studies or panel studies. The adequate epidemiological design to investigate long-term effects of air pollution is a cohort study (Pope and Dockery 1999[1]). An extended discussion of an example from air pollution time-series studies is presented in 6.2.

The magnitude of effect is usually expressed as exposure-response function (see 3.8).

Epidemiological reviews on health effects of air pollution summarizing the effects of several studies give more robust estimates than single study results.

[1] Pope, A. & Dockery, D. 1999. Epidemiology of Particle Effects. In Holgate, S., Samet, J., Koren, H., & Maynard, R. (Eds.), Air Pollution and Health: 673-705. London: Academic Press.

The success of air pollution abatement measures in terms of improved health in the population can be verified only through an ongoing update of the exposure-response functions based on continuous and coordinated air pollution monitoring and health status monitoring and consecutive epidemiological analyses. The changes in chronic health effects may be detected with a longer time lag, due to the nature of long-term effects.

3.8 Exposure-response functions

The exposure-response relationship for a specific pollutant describes the association between exposure and the observed response (health effect). In other words, it estimates how different levels of exposure to a pollutant change the likelihood and severity of health effects.

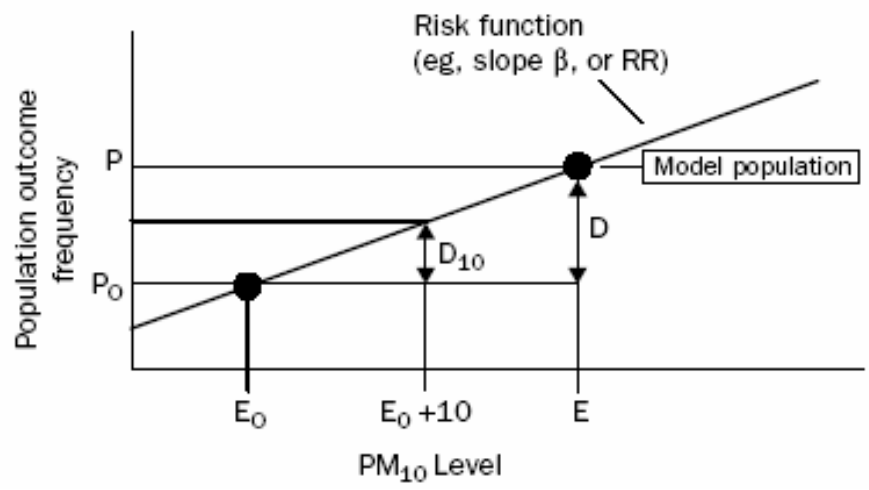


Figure 1 Exposure-response relationship (Künzli et al, 2000)

3.9 Health impact assessment

Health impact assessment is defined as “a combination of procedures, methods and tools by which a policy, program or project may be judged as to its potential effects on the health of a population, and the distribution of those effects within the population”.[2]

Health impact assessment (HIA) allows the estimation of effects of specified actions on the health of a defined population. HIA integrates scientific results and judgments from various thematic disciplines such as toxicology, exposure assessment and epidemiology. The overall air-pollution HIA process involves several linked stages of monitoring of air quality, identifying the population at risk, choosing the endpoint and the exposure-response functions, characterizing the background rates of the chosen endpoint and prediction of the health effects with optional valuation.[3]. This valuation can be the number of excess cases in a population, gain in life expectance, or years of life lost.

[2] WHO European Centre for Health Policy. Gothenburg consensus paper: Health Impact Assessment - Main concepts and suggested approach. WHO Regional Office for Europe, 1999.

[3] Airnet Working Group 4 - Risk and Health Impact Assessment. Air-pollution health impact assessments - an introduction. Hurley, F. and Sanderson, E. 2005. Airnet - A Thematic Network on Air Pollution and Health.

4 Current Status

To assess the current status of local air quality measurements and of health effect and impact assessment within the EU, we performed a detailed analysis along the scheme shown in Figure 2. This figure summarises the necessary steps and information for health impact assessment, a tool to evaluate and compare the burden of air pollution on a European level. It illustrates how the elements of different disciplines, air qualitiy measurements, exposure assessment, health status monitoring and epidemiology/health effect assessment, interrelate. These single elements are then described in more detail in the course of this chapter.

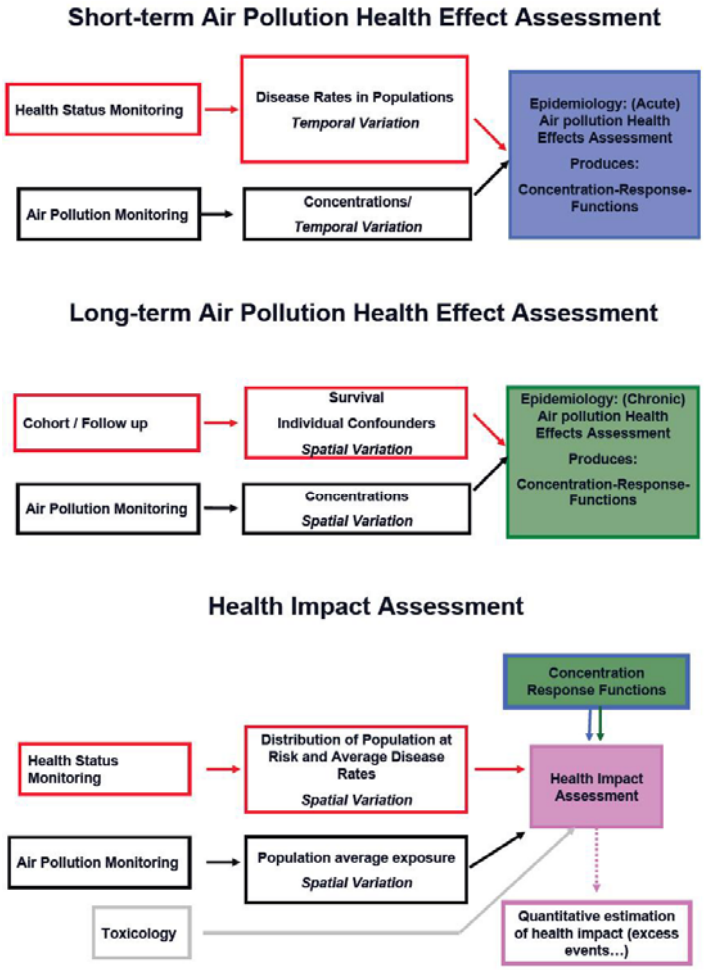


Figure 2 Scheme of the necessary information for a European based health effect and impact assessment

Air pollution health effect assessment enables the estimation of air pollution health effects on regional and/or Member States level. Different strategies for short- and long-term air pollution health effect assessments respectively are needed to obtain quantitative links between an air pollutant and the corresponding health end points (exposure-response functions). Air pollution monitoring, exposure assessment and health status monitoring are basic information needed for both approaches. While short-term health effects can be assessed using time series based on administrative databases, chronic or long-term health effects can only be studied within currently mainly research based cohort / follow-up studies.

The quantitative links between an air pollutant and the corresponding health end points (exposure-response function, risk ratio) are obtained by health effect assessment. These functions are used in health impact assessment (HIA) to give a quantitative measure of the negative impact of air pollutants on human health. This method also allows an estimation of the overall health benefits of abatement strategies. It combines estimated effects with observed population average exposure, population at risk and average disease rates on a spatial resolution that accounts for heterogeneity in exposure levels. Number and type of additional cases of morbidity or mortality are obtained for each of the regions.

4.1 Air pollutants and relevant health endpoints

4.1.1 Limit and target values related to ambient air quality

Over the last 15 years, European epidemiological research has highlighted how air once considered 'safe' may contain pollutants at concentrations that are hazardous to human health. It demonstrated the public-health impact of particulate air pollution, as well as of pollution by ozone, nitrogen dioxide and other gases. In addition evidence was found that long-term exposure to air pollution probably affects people more adversely than short-term exposure.

Table 1 Limit (LV) and target (TV) values set for air pollutants regulated in the EU air quality directives; in brackets: allowed events of exceedence
(*) for protection of ecosystems and vegetation, (**) information threshold

Directive	Targeted pollutant	Type	limit values Target Values			Alert threshold
			annual mean	daily mean	short time values	
1999/30/EC (1st daughter dir.)	SO_2	LV	20 µg/m³ (*)	125 µg/m³ (3 per year)	350 µg/m³; 1 h (24/year)	500 µg/m³
	NO_2	LV	40 µg/m³		200 µg/m³	400 µg/m³
	NOx	LV	30 µg/m³ (*)			
	PM_{10}	LV	40 µg/m³	50 µg/m³ (35 per year)		
	Lead	LV	0.5 µg/m³			
2000/69/EC (2nd daughter dir.)	CO	LV			10,000 µg/m³; 8-h-mean	
	Benzene	LV	5 µg/m³			
2002/03/EC (3rd daughter dir.)	Ozone	TV			120 µg/m³; 8 h mean	180 (**)/ 240 µg/m³
2004/107/EC (4th daughter dir.)	Arsenic (As)	TV	6 ng/m³			
	Nickel (Ni)	TV	20 ng/m³			
	Cadmium (Cd)	TV	5 ng/m³			
	B(a)P	TV	1 ng/m³			

Air quality is one of the areas in which Europe has been very active in recent years. A series of Directives has been introduced to control levels of certain pollutants and to monitor their concentrations in the air. In 1996, the Environment Council adopted Framework Directive 96/62/EC on ambient air quality assessment and management. This directive covers the revision of previously existing legislation and the introduction of new air quality standards for previously unregulated air pollutants, setting the timetable for the development of daughter

directives on a range of pollutants. The obligations of the Member States and general principles of the assessment procedures are laid down in this air quality directive. The Framework Directive 96/62/EC is followed by 4 “daughter directives”.

The daughter directives target different air pollutants and provide for limit or target values the Member States have to comply with as well as for specific rules regarding the assessment procedures and measurement station siting criteria. An overview on the current limit or target values is presented in Table 1.

In the following sections an overview about the health effects for most components considered in the Framework Directive 96/62/EC and the 4 “daughter directives” is given.

4.1.2 Gaseous Air Pollutants

4.1.2.1 *Ozone*

Ozone (O_3) is the most important photochemical oxidant in the troposphere, and as such can react with a wide range of cellular components and biological materials. Ozone is the major component in photochemical smog and it is an indicator of other probably more toxic oxidants (aldehydes, ketones, peroxyacetyl-nitrate (PAN), peroxybutyryl-nitrate (PBN), free radicals) which are generally not measured in the monitoring networks.

Health effects

Ozone presents at least two difficulties in the correct assessment of short-term health effects. First, ozone concentrations have a very strong seasonal pattern with high concentrations almost exclusively in the summer. Second, ozone concentrations tend to be highly correlated with temperature in the summer season. Therefore epidemiological studies need to adjust for season and temperature even more carefully than for other pollutants, in order to provide reliable effect estimates (AIRNET-epidemiology).

Nevertheless, there is a large body of literature that documents associations between short-term increases in ozone concentrations and lung function of children and adults. Associations of short-term exposures to ozone with mortality, respiratory hospital admissions and lung function have been documented in a range of studies including European settings. Recent studies, using sophisticated methods for confounder control, in Europe, Canada and the US have found associations between ozone concentrations and mortality. In the APHEA-1 study, an increase in the one-hour maximum O_3 concentration of 100 µg/m^3 was on average associated with an increase of total mortality of 6%. An increase of the O_3 concentration with 100 µg/m^3 was on average associated with an increase of respiratory mortality of 12% and cardiovascular mortality of 4% (Touloumi et al., 1997; Zmirou et al., 1998). Averaged over 12 studies conducted between 1996 and 2001, an increase of the eight-hour ozone concentration with 100 µg/m^3 was associated with an approximate 4% increase in all-cause mortality (WHO working group, 2003). It is likely that a substantial fraction of the observed health effects is due to ozone itself with other photochemical pollutants possibly contributing to the observed effect.

The epidemiological evidence of long-term effects of ozone is weak. There are few epidemiological studies on the chronic effects of ozone on human health. Incidence of asthma, a decreased lung function growth, lung cancer and total mortality are the main outcomes studied. At levels currently observed in Europe, the evidence linking O_3 exposure to asthma incidence and prevalence in children and adults is not consistent. The strongest evidence exists for impaired lung-function growth and lung function. Repeated exposure, even below the EU limit value of 120 µg/m^3 (8-hour average) may lead to long-term health effects, especially in

more susceptible individuals such as asthmatics, old or obese individuals, those with pre-existing lung disease or suffering from antioxidant deficiency. About 20% of the general population, regardless of airway disease, is more susceptible to an effect of ozone. Specific risk groups include children, the elderly, and people involved in heavy outdoor physical activity.

There is little evidence for an independent long-term O_3 effect on lung cancer or total mortality.

For more information regarding the health effects of ozone please refer to Airnet (Toxicology), EU Commission: Ozone Position Paper, Final version, 1999, WHO (2000).

4.1.2.2 *Carbon monoxide*

Carbon monoxide (CO) is formed mainly from the incomplete combustion of fuels, and has traffic related activities as its main source. Carbon monoxide may serve as indicator for traffic-related air pollutants.

Health effects

Acute CO-poisoning is known to induce adverse health effect in human beings and even cause death. However, there is less certainty about the effects of CO at ambient air levels. The binding of carbon monoxide to haemoglobin in blood is critical to its adverse impact on human health, as the binding reduces the supply of oxygen to peripheral tissue. Therefore, carbon monoxide causes a large number of acute accidental and suicidal deaths in the general population at very high concentrations (well above ambient levels).

At ambient air concentrations of carbon monoxide, healthy individuals do not experience adverse health effects. In individuals with pre-existing heart disease, the effect of carbon monoxide on heart symptoms may occur at concentrations relevant for hot spots/episodes of ambient carbon monoxide pollution.

During pregnancy, endogenous production of carbon monoxide is increased so that maternal COHb levels are usually about 20% higher than the non-pregnant values. At steady state, fetal COHb levels are up to 10–15% higher than maternal COHb levels. There is a well established and probably causal relationship between maternal smoking and low birth weight at fetal COHb levels of 2–10%. In addition, maternal smoking seems to be associated with a dose-dependent increase in perinatal deaths and with behavioural effects in infants and young children (WHO, 2000).

For more information regarding the health effects of carbon monoxide please refer to Airnet (Toxicology), EU Commission: Carbon Monoxide Position Paper, 1999.

4.1.2.3 *Sulphur dioxide*

The main anthropogenic sources for sulphur dioxide (SO_2) are combustion of fossil fuels containing sulphur (mainly coal and heavy oils), and the smelting of ores containing sulphur. In many urban areas of Western Europe and North America, concentrations of sulphur dioxide have continued to decline in recent years as a result of controls on emissions and changes in fuel use. Annual mean concentrations in such areas are now mainly in the range 20–60 $\mu g/m^3$, with daily means seldom higher than 125 $\mu g/m^3$. In large cities where coal is still widely used for domestic heating or cooking, however, or where there are poorly controlled industrial sources, concentrations may be 5–10 times these values.

Health effects

Considerable epidemiological evidence has accumulated supporting an association of SO_2 exposure on mortality, respiratory and cardiovascular health. It is unknown if these associations are caused by other pollutants or whether SO_2 has a harmful effect even at very low levels.

Increases in mortality have been associated with increases in short-term exposure to SO_2 in Europe and Asia. A meta-analysis of daily mortality from 12 European cities (APHEA-2) found an approximately 3% increase in mortality associated with an increase of 50 μg/m^3 in SO_2 concentrations (Katsouyanni et al., 1997). However, other studies reported absence of associations between mortality and SO_2. A meta-analysis of Spanish cities found little evidence of an association (Schwartz et al., 2001). Correlation between ambient concentrations of SO_2 and other pollutants may have led to difficulty in distinguishing effects that can be attributed in part or wholly to SO_2. A time-series analysis of mortality in London over a 15-year period found that all effects could be attributed to short-term exposure to particulates and not to SO_2 (Schwartz et al., 1990). Other studies have, however, investigated and found independent effects from SO_2. Time-series analyses in London and Hong Kong, using identical methodology in both cities, found increases in respiratory and cardiac hospital admissions were associated with increases in SO_2 (Wong et al., 2002).

Sulphur dioxide exposure has also been associated with day-to-day hospital admissions for respiratory and cardiovascular diseases. Especially asthmatics can be more responsive than healthy subjects and may possibly react at concentrations pertinent to hot spots.

For more information regarding the health effects of ozone please refer to Airnet (Epidemiology), Airnet (Toxicology), EU Commission: Sulfur Dioxide Position Paper, 1997, WHO (2000).

4.1.2.4 *Nitrogen dioxide*

Nitrogen dioxide (NO_2) is one of the major components in air pollution in densely populated areas nowadays. Levels of NO_2 vary widely because a continuous baseline level is frequently present, with peaks of higher levels superimposed. Regional background annual mean concentrations are in the range 0.4–9.4 μg/m^3. Outdoor urban levels have an annual mean range of 20–90 μg/m^3 and hourly maxima in the range 75–1015 μg/m^3. NO_2 is strongly correlated with particles, because both come from the same combustion sources and NO_2 is converted in the atmosphere to particulate nitrates and thus contributes to fine particle mass. Therefore it is very difficult to differentiate the independent effects of NO_2 and other pollutants.

Health effects

Health effects from NO_2 in epidemiological studies may potentially result from NO_2 itself or its reaction products including O_3 and secondary particles. In many studies when adjustment for particles was made, the risk estimates were greatly reduced and often became non-significant. In some studies, however, especially in Europe, the strongest effect was found for NO_2 whereas particulate matter had a weaker effect. On the basis of these findings, one might speculate that NO_2 is a better marker of local traffic than particulate matter measured as PM_{10} or $PM_{2.5}$.

There have been several time-series studies published on the effects of NO_2 on daily hospital admissions for respiratory disorders, including asthma in children and adults (Sunyer at al., 1997, Anderson, 1997, Tenias et al., 1998, Hajat et al., 1999, Fusco et al., 2001). In comparison with the number of studies on respiratory diseases, fewer studies are available on hospital admissions for cardiovascular diseases. Some studies found positive associations with NO_2 (Burnet et al., 1997), whereas other studies did not (Schwartz 1997, Morris et al., 1995). In

some of the positive studies, the effect estimates are smaller and sometimes non-significant when the investigators corrected for particle concentrations.

Several panel studies have evaluated the role of air pollutants on the aggravation of symptoms among patients with respiratory conditions. Most studies concern asthmatic children, while far fewer observations relate to adult or elderly asthmatics or COPD patients (Braun-Fahrlander et al., 1992, Linaker et al., 2000, Peters et al., 2000). The outcomes of interest vary from symptoms and medication use, to changes in peak expiratory flow rate or in spirometric flow and volume. Asthmatic individuals are more sensitive than healthy subjects, reacting to high-episode concentrations of NO_2 gas with increased narrowing of airways and responsiveness of the airways to irritants and allergens.

There are fewer epidemiological studies on long-term respiratory effects of NO_2 than on particulate matter, but new evidence has been provided in recent years. Both cross-sectional and longitudinal studies indicate an association between NO_2 and lung function (Peters et al., 1999, Gauderman, 2002, Schindler, 1998). Recently published studies document that NO_2, as marker of a complex mixtures of traffic-related combustion pollution, can have higher spatial variation than particle mass. In addition, these studies reported adverse effects on the health of children living in the areas characterized by higher levels of NO_2 even when the overall level was low. They also show that these associations cannot be completely explained by co-exposure to particles, but that other components in the mixture (such as organic carbon and acid vapor) might explain part of the association.

For more information regarding the health effects of NO_2 please refer to Airnet (Epidemiology), Airnet (Toxicology), EU Commission: Position Paper on Air Quality, Nitrogen Dioxide, 1997, WHO 2000, WHO working group, 2003.

4.1.2.5 *Benzene*

Benzene is a gaseous pollutant that is ubiquitous in the environment. It is used as a constituent in motor fuels; as a solvent for fats, waxes, resins, oils, inks, paints, plastics, and rubber; in the extraction of oils from seeds and nuts; and in photogravure printing. It is also used in the manufacture detergents, explosives, pharmaceuticals, and dyestuffs. In addition, the public is exposed to benzene as a result of direct and indirect cigarette smoke, home use of solvents and gasoline, and leaking underground storage tanks. Because many of these sources are located indoors, benzene concentrations inside homes are generally higher than those outdoors. Personal benzene exposures also tend to be higher than those outdoors and were highest in urban than in suburban locations. Benzene concentrations have been shown to be highest in motor vehicles, with concentrations inside motor vehicles up to 8 times that of corresponding ambient concentrations. Correspondingly, short-term (1-hr) personal benzene exposures have also been shown to be highest during motor vehicle-related activities, such as commuting by car or bus and during activities at gasoline stations (Suh et al., 2005).

Health effects

Benzene is absorbed into the human body via various pathways, including inhalation, dermal contact, and ingestion. Exposures to benzene, even at low doses, have been linked to a variety of acute and chronic adverse health effects. Inhalation exposures to benzene, for example, may result in a variety of neurologic symptoms and even death after exposures to very high levels.

Numerous reviews over the years have described and evaluated adverse health effects associated with exposure to benzene (ATSDR, 1993, Paustenbach et al., 1993, Hughes et al., 1994, Jex and Wyman, 1996). However, all of these effects were associated with occupational

exposures which involve much higher benzene concentrations than are encountered in the general environment. Most occupational exposures are presented as 8 hour time weighted averages (TWAs), and exposures outside the working day are not considered. Furthermore, few of the occupational studies include exposure data for women or for people over the age of 65 years. Studies in children are scarce. The most significant adverse effects from prolonged exposure to benzene are haematotoxicity, genotoxicity and carcinogenicity.

Hematologic effects have been observed after chronic or long-term inhalation of benzene, which has been shown to cause blood disorders through damage to the bone marrow. Several diseases (such as aplastic anemia, excessive bleeding, and damage to the immune system) may develop from chronic benzene exposures, as a result of changes in blood levels of antibodies and loss of white blood cells.

In addition, chronic benzene exposures were shown to produce both structural and numerical chromosomal aberrations in humans and to result in increased incidence of leukemia in individuals occupationally exposed to benzene. In humans, haematological effects of varying severity have occurred in workers occupationally exposed to high levels of benzene (WHO, 2000a).

The carcinogenicity of benzene has been established both in humans and in laboratory animals. An increased mortality from leukaemia has been demonstrated in workers occupationally exposed. Chronic benzene exposure can result in bone marrow depression. Some studies in humans have demonstrated chromosomal effects at mean workplace exposures as low as 4–7 mg/m^3 (WHO, 2000a). As a result, the U.S. EPA has classified benzene as a Group A known human carcinogen. On the basis of results from human and animal studies, benzene has been estimated to have an inhalation unit risk for cancer of $8.3 * 10^{-6}$ $(\mu g/m^3)^{-1}$.

4.1.3 Particulate matter

The term particulate matter (PM) is used to describe airborne solid particles and/or droplets. These particles may vary in size, composition and origin. Several different indicators have been used to characterize ambient PM. Classification by size is quite common because size governs the transport and removal of particles from the air and their deposition within the respiratory system, and is at least partly associated with the chemical composition and sources of particles. Based on size, urban PM tends to be divided into three principal groups: coarse, fine and ultrafine particles. The border between the coarse and fine particles is usually fixed by convention at 2.5 µm in aerodynamic diameter ($PM_{2.5}$) for measurement purposes. The border between fine and ultrafine particles lies at about 0.1 µm. PM_{10} is used to describe particles with an aerodynamic diameter smaller than 10 µm (50% cut off).

Particles in the PM_{10} size fraction may reach the upper part of the airways and lung. Coarse particles tend to deposit higher up in the airways whereas fine particles tend to deposit in the lower airways and lungs. Smaller particles (in particular $PM_{2.5}$) penetrate more deeply into the lung and may reach the alveolar region. Several studies have documented that especially the fine fraction ($PM_{2.5}$) of PM_{10} is associated with health effects (mortality, lung function). Ultrafine particles contribute only slightly to PM_{10} mass but may be important from health point view because of the large numbers and high surface area. They are produced in large numbers in urban areas by especially combustion processes.

It is unlikely that all particles, irrespective of size/chemical composition/source, have the same health effect. Both, coarse and fine PM fraction seem capable for inducing toxicity and hence health effects. Whether the ultrafine PM fraction, tested at near-ambient levels, is also toxic,

remains more uncertain. It has to be noted that both particle mass and number concentrations are air quality **indicators** and are not inevitably a measure for toxicity.

4.1.3.1 *$PM_{2.5}$ and PM_{10}*

Many studies, especially those conducted since the early 1990s, have documented that short-term increases in particulate-matter air pollution are associated with increased daily mortality and hospital admissions for respiratory and cardiovascular disease.

The APHEA-1 and APHEA-2 studies have provided a database to evaluate health effects in a large number of cities in Europe. The APHEA-2 study found an average increase of 6% in daily total mortality when the PM_{10} concentration increased by 100 µg/m^3. An increase with 100 µg/m^3 is approximately the difference between a low- and high-pollution day in many European cities (Katsouyanni et al., 2001).

The results of the APHEA-2 study are consistent with a large number of other European studies and studies conducted in the US and Canada. The largest study is the NMMAPS study conducted in 90 US cities. It demonstrated an average increase of 0.21 % of total mortality when the PM_{10} concentration increased by 10 µg/m^3 (Dominici et al., 2005).

The APHEA-2 study also showed that hospital admissions for asthma increased with increasing PM_{10} concentration. While effects on mortality are mostly observed in the elderly (>65 yr), effects associated with a 100 µg/m^3 of PM_{10} on asthma hospital admissions were very similar for the age groups 0-14 yr (12% increase), 15-64 yr (11% increase) and >65 yr (10% increase). Hospital admissions for cardiovascular disease also increased with increasing PM_{10} concentrations. Many studies in the US, Canada and Europe have largely supported these associations.

In addition to time-series studies of routinely available data on health status and air pollution, researchers have performed studies in which they followed a panel of subjects for several months. Typical outcomes evaluated in these panel studies include acute respiratory symptoms, medication use for respiratory/cardiovascular disease and lung function. Most studies reported that at increased PM_{10} concentrations, the occurrence of symptoms of the lower respiratory tract (e.g. wheeze, shortness of breath), the use of bronchodilators to relieve respiratory symptoms and a low lung function were increased (Airnet, Epidemiology).

In the EU-funded Ultra study, the panel design was used to study cardiac-endpoints (such as cardiac symptoms) and physiologic variables (such as heart-rate variability, measured with a simple electrocardiogram). It was found that increased $PM_{2.5}$ concentrations were associated with increased ST-segment depressions, which is an indication for myocardial ischemia (‘heart attack’) (Pekkanen et al., 2002). Other studies have found that blood coagulability was increased with increasing air pollution. Another study found that life-threatening arrhythmia (disturbance of the normal rhythm of the heart) in patients with an implanted defibrillator was increased with increasing $PM_{2.5}$ concentrations (Peters et al., 2000).

Two cohort studies in the US (the Harvard Six City Study and the American Cancer Society Study) have documented that subjects living in cities with higher long-term average PM_{10}/$PM_{2.5}$ concentrations died earlier than subjects living in cities with low air pollution (Dockery et al., 1993, Pope et al., 1995). Because of the importance of these studies in health impact assessment, an extensive reanalysis of these studies was conducted under the supervision of the US Health Effects Institute. The reanalysis supported the conclusions of the original papers.

In Europe, there are no studies available to evaluate the relationship between increased long-term exposure to PM_{10}/$PM_{2.5}$ and mortality. Two cohort studies did suggest that mortality was

associated with long-term average traffic-related air pollution in Europe (Hoek et al., 2002, Nafstad et al., 2004). PM_{10} and probably $PM_{2.5}$ concentrations, especially in Central/Eastern and Southern Europe, exceed the concentrations evaluated in the two US studies. The available evidence suggests that the public-health impact of long-term exposure may considerably exceed the impact of short-term exposures.

More information is available in Europe on effects of long-term exposure to PM_{10} on lung function and chronic respiratory symptoms in children. A long term study in three areas in the former East Germany found an association between the PM_{10}/TSP concentration in the city of residence, presence of chronic respiratory (especially bronchitic) symptoms and lung function growth (Heinrich et al., 2000, Heinrich et al., 2002, Frye et al., 2003). Recently, the EU-funded TRAPCA study suggested that respiratory symptoms were increased in one-two year-old children who lived in homes with higher traffic-related $PM_{2.5}$ concentrations (Gehrig et al., 2002, Brauer et al., 2003).

For more information regarding the health effects of $PM_{2.5}$ and PM_{10} please refer to Airnet (Toxicology), EU Commission: Second Position Paper on Particulate Matter, 2004, WHO 2000, WHO working group, 2003, WHO regional publications, 1999.

4.1.3.2 *Coarse fraction $PM_{2.5-10}$*

Most time-series studies of daily mortality did not find a significant association with coarse particles. The strongest support for an effect of the coarse fraction on the daily number of deaths comes from areas with relatively high concentrations of coarse particles, Phoenix (Mar et al., 2000), Mexico City (Castillejos et al., 2000) and Coachella Valley (Ostro et al., 2000). Few studies have analysed fine and coarse PM jointly (Brunekreeef and Forsberg, 2005). Some of them showed that the effects of coarse PM were reduced after adjustment for fine PM but the effects of fine PM remained after adjustment for coarse PM. In Santiago coarse PM were more important than fine PM only in summer when the coarse fraction seemed to have an independent effect (Cifuentes et al., 2000). Very few data exist that allow estimates of long-term effects of coarse PM on morbidity.

There are more than 10 studies of short-term effects on admissions and emergency visits analysing effects of both the coarse and fine fraction. Five of these studies are from Toronto, Canada, using different outcomes, study populations and particle-exposure metrics. The results indicate that the coarse fraction may be important especially for respiratory admissions, asthma and obstructive lung disease (Burnett et al., 1999, Moolgavkar et al., 2000, Burnet et al., 2001, Lin et al., 2002). In studies of COPD, asthma and respiratory admissions coarse PM has a stronger or as strong short-term effect as fine PM (Brunekreeef and Forsberg, 2005).

For more information regarding the health effects of the coarse fraction of particles please refer to Airnet (Epidemiology), Airnet (Toxicology), WHO working group, 2003.

4.1.3.3 *Ultrafine particles*

There are currently very few published epidemiological studies on the health effects of ultrafine particles or nanoparticles (diameter below 0.1 µm) in urban air. However, the limited number of available epidemiological studies suggests that daily variation in the concentration of ultrafine particles in urban areas is associated with several health effects.

A panel study of asthmatics from Erfurt suggested that ultrafine particles are more strongly associated with respiratory outcomes than fine-particle fractions (Peters et al. 1997). This was also seen in a panel study of adult asthmatics in Helsinki (Penttinen et al., 2001a). Other panel

studies of asthmatic children in Finland (Pekkanen et al., 1997, Tiittanen et al., 1999) or asthmatic adults in Helsinki (Penttinen et al., 2001b) and Erfurt have shown similar associations of ultrafine and fine particles with respiratory health. In a 3.5-year time-series study of mortality in Erfurt, both ultrafine and fine particles were associated with mortality and the effects seemed to be largely independent of each other (Wichmann et al., 2000).

The EU-funded ULTRA study looked at the health effects of fine and ultrafine particles among coronary heart-disease patients. Ultrafine particles were only weakly associated with some symptoms. In Helsinki, both ultrafines and $PM_{2.5}$ were independently associated with signs of myocardial ischemia, measured as risk of ST-segment depression during a light exercise test (Pekkanen et al., 2002).

It is unlikely that ultrafine particles explain all the health effects found in previous epidemiological studies associated with daily variations in PM_X, due to the low correlation between the two particle fractions (PM_X – UFP). However, ultrafine particles are a marker of locally emitted primary particles and represent an additional independent characteristic of urban aerosol not fully characterized by $PM_{2.5}$ and PM_{10}. Although there is currently a lack of measurement standards, and measurement techniques for routine measurements of UFP, we recommend to develop those standards in the future.

For more information regarding the health effects of ultrafine particles please refer to Airnet (Epidemiology), Airnet (Toxicology), WHO working group, 2003.

4.1.3.4 *Secondary pollutants (sulphate and nitrate)*

Secondary particulate matter refers to the particles of semi- to low volatility formed via atmospheric chemical processes from the gaseous emissions of precursor pollutants. Secondary sulphate and nitrate particles are formed by atmospheric reactions of sulphur oxides and nitrogen oxides initially released as gases and are usually a dominant component of fine particles. They can be transported over hundreds of kilometres and contribute to the regional background concentration of particles. In general, the particles are not pure sulphate or nitrate particles, but consist of a carbonaceous core and a variety of chemical substances ranging from transition metals to oxidised hydrocarbons.

Health effects

Much of the evidence for the health effects of sulphate particles originates from research in Canada, where sulphates were measured over extended periods of time. Studies associating daily mortality rates with different components of particulate matter found evidence in eight Canadian cities for sulphates playing a major role (Burnet et al., 2000). Coherently, hospital admissions for respiratory as well as cardiovascular diseases were observed in association with sulphate concentrations (Burnett et al., 1995).

An association with mortality has been observed in the American Cancer Society Study (Pope et al., 1995). Sulphates seem to contribute to the observed health risk in association with particulate matter whenever they were measured. Because in animal experiments it has generally not been possible to find harmful effects of sulphate aerosols – even at concentrations much higher than ambient, sulphate particles are considered as surrogate measures for regionally transported and aged particles. Note that an important difference between sulphate particles in north-east America and Europe is that the sulphate particles in north-east America are acidic and peak in summer, whereas they are not acidic in Europe and peak in winter. Because of the high ammonia concentrations in ambient air in Europe, acid sulphates are completely neutralised.

The database concerning health effects of inhaled nitrates is limited. There are no epidemiological studies investigating the health effects of nitrate particles (Schlesinger et al., 2006). Some controlled human exposure studies have been conducted using sodium and ammonium nitrate aerosols in both normal and potentially susceptible individuals such as asthmatics. The only effects noted were decreases in airway conductance and peak-expiratory flow–volume curves in subjects with influenza (Schlesinger and Cassee, 2003). Thus, these results suggest that there are likely no adverse effects, as far as measured cardiopulmonary function is concerned, from ambient levels of nitrate aerosols, even in presumably more sensitive asthmatic members of the general population. It should, however, be noted that some of the potentially more sensitive cardiopulmonary indices of response, such as heart rate variability, have not yet been assessed in controlled studies with nitrate particles.

Hence, measurements of nitrate, sulphate, and ammonia are not recommended for the routine health related measurements of PM. Nevertheless it should be monitored at selected sites, e.g. in the superregions over Europe.

4.1.3.5 Soot (Black Smoke)

Combustion particles, including those from traffic, significantly contribute to $PM_{2.5}$ concentrations in urban environments. These particles are characterised by a carbonaceous core that can be measured by soot or elemental carbon measurements. Many monitoring programs for air quality in Europe include measurements of so-called black smoke content. The black-smoke method is traditionally used to measure the blackness of PM and is based on the light reflectance of PM. Black smoke, soot content and elemental carbon in PM are usually highly correlated. The black-smoke method has been applied for many decades. In the 1950s and 1960s, it provided information on air pollution related to the combustion of coal. Starting in the 1970s, it was used as an indicator of diesel emissions from road traffic. Black smoke is relevant for road traffic with diesel engines, non-road transport by ships and trains (with diesel locomotives) and power generation by oil and coal. Thanks to this tradition of measuring black smoke (BS) in Europe, measurements were available to study the association between BS and health, e.g. in the APHEA study. Some other studies have used surrogate measurements of traffic related particles such as proximity of the residential address or school to major roads.

Health effects

An increase of 10 $\mu g/m^3$ black smoke was associated with 0.6% increase in daily mortality in 12 European cities in 1997 as part of the APHEA I study (Katsouyanni et al., 1997). This result was confirmed in a follow-up study estimating a 0.6% increased risk for daily mortality in association with a 10 $\mu g/m^3$ increase in black smoke or PM_{10} based on data from 29 European cities (Katsouyanni et al., 2001). These studies could not distinguish between the results of PM_{10} and black smoke, mainly because concurrent measurements of both particle indices were only rarely available.

A study in Dublin showed that black-smoke concentrations decreased by 36 $\mu g/m^3$ after a coal ban in 1990 (Clancy et al., 2002). In the following years, non-trauma deaths were reduced by 6% and deaths due to cardiovascular diseases decreased by 10%. The Dublin study indicated that the benefit from reducing black-smoke concentrations exceeded the benefit one would have predicted on the basis of the APHEA studies' results.

One study from the Netherlands assessed the association between long-term concentrations of black smoke and mortality (Hoek et al., 2002). Living near a major road, i.e. within a distance of 50m to a major road or 100m to a highway was associated with a relative risk of 1.95 (95% confidence limit: 1.09 to 3.51). The estimated risk for the background black smoke

concentrations (after converting black smoke into $PM_{2.5}$) was a 6% increase in mortality for every 10 µg/m^3 in 'background' $PM_{2.5}$. The results for the background levels from the Netherlands are consistent with the 16-year follow-up of 500,000 adults in the US (Pope et al., 2002) indicating that the true risk is underestimated based on urban background concentrations only.

Eventhough, black smoke and related measurement techniques for e.g. elemental carbon generally show a significant correlation to health effects, there are current problems of comparability for all methods determing "soot carbon". We see a necessity to develop a standardised method for Europe and subsequently the introduction of that method to the general network. Black smoke and/or a related method should certainly be applied at superregion level.

For more information regarding the health effects of Black Smoke please refer to Airnet (Epidemiology) and WHO Europe, 2005.

4.1.3.6 *Polycyclic aromatic hydrocarbons*

Polycyclic aromatic hydrocarbons (PAH) are formed during incomplete combustion or pyrolysis (chemical decomposition by the action of heat) of organic materials such as oil, gas, coal and wood (WHO, 2000b). PAH may be present in the vapor phase as well as bound to PM. The most commonly studied PAH is benzo[a]pyrene (BaP). BaP is sometimes used as an indicator for the complex mixture of PAH. Risk analysis has traditionally focused on the carcinogenic properties.

Health effects

Polycyclic aromatic hydrocarbons include some powerful carcinogens and toxicological evidence indicates that they have the potential to contribute to lung carcinogenesis at ambient air pollution levels. It should be noted that most epidemiological studies of the effects of exposure to mixtures of PAH compounds express their results in terms of the concentration of BaP present in the mixture studied. Several recent studies have suggested that exposure to PAH may have other effects than cancer. Foetuses in particular are considered to be highly susceptible to a variety of toxicants because of their exposure pattern and physiologic immaturity (Sram, 1999). Their developing organ systems can be more vulnerable to environmental toxicants during critical periods, due to higher rates of cell proliferation or changing metabolic capabilities. Therefore, prenatal exposure to environmental pollution can result in some adverse reproductive outcomes. Data on the impact of carcinogenic PAH on pregnancy outcome have only been collected during the last decade. Such data significantly enhances the scientific knowledge base and must be incorporated into current risk-assessment procedures to improve children's health in polluted regions all over the world.

For more information regarding the health effects of PAH please refer to Airnet (Epidemiology), Airnet (Toxicology) and EU Commission Ambient air pollution by Polycyclic Aromatic Hydrocarbons (PAH). Position Paper, 2001.

4.1.4 Metallic pollutants

In comparison to gaseous substances, the risk assessment of metallic compounds as constituents of the aerosol is rendered more difficult due to the following:

- Metallic and metalloid compounds are present as different chemical species with different toxic and carcinogenic properties.

- A number of physico-chemical factors such as water solubility, particle size distribution and surface enrichment or encapsulation within the aerosol can affect bioavailability.

In ambient air, metals, metalloids and their compounds are mainly encountered as part of particulate matter. They may be present in the non soluble, non stochiometric mixture phase (for example as spinels) or as soluble ionic compounds (salts).

4.1.4.1 *Nickel*

Nickel is present throughout nature and is released into air and water both from natural sources and as a result of human activity. Nickel levels in ambient air are in the range 1–10 ng/m^3 in urban areas, although much higher levels (110–180 ng/m^3) have been recorded in heavily industrialized areas and larger cities. There is, however, limited information on the species of nickel in ambient air. Exposure to nickel levels of 10–100 mg/m^3 have been recorded for occupational groups, with documented increased cancer risk. Exposure levels in the refining industry are currently usually less than 1–2 mg/m^3, often less than 0.5 mg/m^3.

Health effects

Experimental and epidemiological data indicate that the nickel species in question is important for risk estimation. Work-related exposure in the nickel-refining industry has been documented to cause an increased risk of lung and nasal cancers. Nickel has a strong and prevalent allergenic potency. There is no evidence that airborne nickel causes allergic reactions in the general population, although this reaction is well documented in the working environment. The key criterion for assessing the risk of nickel exposure is its carcinogenic potential.

Epidemiological evidence from the nickel-refining industry indicates that sulfidic, oxidic and soluble nickel compounds are all carcinogenic. Exposure to metallic nickel has not been demonstrated to cause cancer in workers. Several theories have been suggested for the mechanisms of nickel tumorigenesis. All of these assume that the nickel ion is the ultimate active agent.

On the basis of the underlying concept that all nickel compounds can generate nickel ions that are transported to critical sites in target cells, IARC has classified nickel compounds as carcinogenic to humans and metallic nickel as possibly carcinogenic to humans.

For more information regarding the health effects of nickel please refer to WHO (2000) and EU Commission: Ambient air pollution by As, Cd and Ni compounds. Position Paper, 2000.

4.1.4.2 *Arsenic*

There are many arsenic compounds, both organic and inorganic, in the environment. Airborne concentrations of arsenic range from 1 ng/m^3 to 10 ng/m^3 in rural areas and 30 ng/m^3 in non-contaminated urban areas. Near emission sources, such as nonferrous metal smelters and power plants burning arsenic-rich coal, concentrations of airborne arsenic can exceed 1 µg/m^3.

Health effects

Inorganic arsenic can have acute, sub acute and chronic effects, which may be either local or systemic. Lung cancer is considered to be the critical effect following inhalation. An increased incidence of lung cancer has been seen in several occupational groups exposed to inorganic arsenic compounds. Some studies also show that populations near emission sources of inorganic arsenic, such as smelters, have a moderately elevated risk of lung cancer.

For more information regarding the health effects of arsenic please refer to WHO (2000) and EU Commission: Ambient air pollution by As, Cd and Ni compounds. Position Paper, 2000.

4.1.4.3 *Cadmium*

The general population is exposed from breathing cigarette smoke or eating cadmium contaminated foods. Assuming, however, that the only route of exposure is by inhalation, an indirect estimate of the risk of renal dysfunction or lung cancer can be made on the basis of data collected in industrial workers.

Health effects

Cadmium damages the lungs, can cause kidney disease, and may irritate the digestive tract. Cadmium in ambient air is transferred to soil by wet or dry deposition and can enter the food chain. However, the rate of transfer from soil to plant depends on numerous factors (type of soil and plant, soil pH, use of fertilizers, meteorology, etc.) and is impossible to predict.

Pooled data from studies, in which the relationships between the occurrence of tubular proteinuria and cumulative cadmium exposure were examined, show that the prevalence of tubular dysfunction increases sharply at a cumulative exposure of more than 500 µg/m^3-years. Some studies suggest that a proportion of workers with cumulative exposures of 100–400 µg/m^3-years might develop tubular dysfunction.

For more information regarding the health effects of cadmium please refer to WHO (2000) and EU Commission: Ambient air pollution by As, Cd and Ni compounds. Position Paper, 2000.

4.1.4.4 *Lead*

Average air lead levels are usually below 0.15 µg/m^3 at non-urban sites. Urban air lead levels are typically between 0.15 and 0.5 µg/m^3 in most European cities. Additional routes of exposure must not be neglected, such as lead in dust, a cause of special concern for children. The relationship between air lead exposure and blood lead has been shown to exhibit downward curvilinear if the range of exposures is sufficiently large. The level of lead in blood is the best available indicator of current and recent past environmental exposure, and may also be a reasonably good indicator of lead body burden with stable exposures. Biological effects of lead will, therefore, be related to blood lead as an indicator of internal exposure.

Health effects

Adverse health effects to be considered in the adult organism include elevation of free erythrocyte protoporphyrin, whereas for children cognitive deficit, hearing impairment and disturbed vitamin D metabolism are taken as the decisive effects. Currently measured “baseline” blood lead levels of minimal anthropogenic origin are probably in the range 10–30 µg/l. International expert groups have determined that the earliest adverse effects of lead in populations of young children begin at 100–150 µg/l. Cognitive effects in lead workers have not been observed at blood lead levels below 400 µg/l. Reductions in nerve conduction velocity were found in lead workers at blood levels as low as 300 µg/l. Elevation of free erythrocyte protoporphyrin has been observed at blood levels of 200–300 µg/l. Delta-aminolaevulinic acid dehydrase (ALAD) inhibition is likely to occur at blood levels of about 100 µg/l. Haematocrit values below 35% have not been reported at blood levels below 200 µg/l; this is also true for several enzyme systems, which may be of clinical significance.

It can be assumed that inhalation of airborne lead is a significant route of exposure for adults (including pregnant women) but is of less significance for young children, for whom other

pathways of exposure such as ingested lead are generally more important. To prevent further increases of lead in soils and consequent increases in the exposure of future generations, air lead levels should be kept as low as possible. Some epidemiological studies have indicated effects at blood lead levels below 100 µg/l.

For more information regarding the health effects of lead please refer to WHO (2000).

4.1.5 Conclusions Air Pollutant and Health Endpoints

4.1.5.1 *Gaseous air pollutants*

Associations of short-term exposures to gaseous pollutants with mortality, respiratory hospital admissions and lung function have been documented in a range of studies including European settings. These associations are consistent with the effects found in animal and human-controlled exposure studies. In contrast, the epidemiological evidence of long-term effects is weaker. The strongest evidence for ozone exists for impaired lung-function growth and lung function.

In recent years new evidence on an association between NO_2 and lung function has been provided by cross-sectional and longitudinal studies. However, since NO_2 is an important constituent of combustion generated air pollution and is highly correlated with other combustion products, it is unclear to what extent the health effects observed in epidemiological studies are attributable to NO_2 itself or to other correlated pollutants including ultrafine particles. In general, epidemiological studies are limited in their ability to separate the health effects for one specific pollutant. In many studies when adjustment for particles was made, the risk estimates for gaseous pollutants were greatly reduced and often became non-significant. However, recent studies on indoor NO_2 concentrations have added evidence on adverse effects of NO_2 on respiratory symptoms in children. They also show that these associations cannot be completely explained by co-exposure to PM, but that other components in the mixture (such as organic carbon and acid vapour) might explain part of the association. Additionally, NO_2 concentrations closely follow vehicle emissions in many situations so that NO_2 levels are generally a reasonable marker of exposure to traffic related emissions.

Considerable epidemiological evidence has accumulated supporting a deleterious effect from SO_2 exposure on mortality, respiratory and cardiovascular health. Nevertheless, there is still considerable uncertainty as to whether SO_2 has a harmful effect at very low levels or, rather, is a surrogate for other correlated substances.

Hence, the focus for gaseous air pollutants in the next years should be on O_3, NO_2 and SO_2 and to a lesser extent (more hot-spot related) on benzene.

4.1.5.2 *Particulate matter*

Studies assessing the health effects of PM are consistently showing adverse health effects at exposures experienced by urban populations in cities throughout the world, in both developed and developing countries. The epidemiological evidence shows adverse effects of particles after both short-term and long-term exposures. The available evidence suggests that the public-health impact of long-term exposure may considerably exceed the impact of short-term exposures. The range of effects is broad, affecting the respiratory and cardiovascular systems and extending to children and adults and to a number of large, susceptible groups within the general population. The risk for various outcomes has been shown to increase with exposure and there is little evidence to suggest a threshold below which no adverse health effects would be anticipated.

The most extensive epidemiological evidence is largely based on studies using PM_{10} as the exposure indicator. PM_{10} includes both the coarse (PM10-PM2.5) and fine (PM2.5) fraction of particles considered to contribute to the health effects observed in urban environments. In most urban environments, both coarse and fine mode particles are likely to be prominent. However, only limited information is available to judge which particle exposure produces the highest risk. Several studies conducted in the US have documented that especially the fine fraction ($PM_{2.5}$) of PM_{10} is associated with health effects (mortality, lung function). This does not imply that the coarse fraction of PM_{10} is innocuous.

It is recommended to monitor $PM_{2.5}$ and PM_{10} at all monitoring stations. As the coarse PM concentrations could be obtained by substraction of measured $PM_{2.5}$ from measured PM_{10} concentrations they will be automatically availably at all $PM_{2.5}$ monitoring stations. Note that if the measurement is indirect the instrumental measurement error might be larger.

In addition to PM2.5 and PM10, ultra fine particles (UFP) have recently attracted significant scientific and medical attention. While there is considerable toxicological evidence of potential detrimental effects of UFP on human health, the existing body of epidemiological evidence is insufficient to reach a conclusion on the exposure-response relationship to UFP.

Although there is currently a lack of measurement standards, and measurement techniques for routine measurements of UFP, we recommend to develop those standards in the future.

In toxicological and controlled human exposure studies, several physical, biological and chemical characteristics of particles have been found to elicit cardiopulmonary responses. Possibly relevant chemical characteristics include the content of transition metals, crustal material, secondary components such as sulphates and nitrates, polycyclic aromatic hydrocarbons and carbonaceous material, reflecting the various sources that contribute to PM in the atmosphere.

In many time series and in some of the cohort and cross sectional studies, sulphates are found to predict adverse effects well. It has been suggested that this may be related to interactions between sulphate and iron in particles but it should be pointed out that in animal experiments, it has generally not been possible to find deleterious effects of sulphate aerosols even at concentrations much higher than ambient.

In several recent European studies, BS was found to be at least as predictive of negative health outcomes as PM_{10} or $PM_{2.5}$. These findings indicate that black smoke, which is closely-related in the modern urban setting with diesel engine exhaust, could serve as a useful marker in epidemiological studies, perhaps even retrospective analyses using the historic data available in many European urban areas.

Data from a number of occupational health studies suggest that there is an association between lung cancer and exposure to PAH compounds. The most important exposure route for lung cancer would appear to be via inhalation. Several PAH have been accepted as probable or possible human carcinogens, most of them are known to be associated with airborne particles. BaP, a probable human carcinogen found in appreciable concentrations in the atmosphere, can be used as a marker of the carcinogenic risk of airborne PAH compounds despite not necessarily being the most potent carcinogen present. Data exist from occupational health studies which can be used as the basis for estimating the risk to human health posed by ambient levels of PAH.

Monitoring of nitrate, sulphate and ammonium is recommended for the superregions but not for the general network since it does not be likely to be health relevant. Monitoring of the “soot compound”, either by BS or another method, is currently only recommended for the superregions. The lack of a comparable method and standard is the main reason for this

recommendation despite its correlation to health effects. We see a necessity to develop a standardised method for Europe and subsequently the introduction of that method to the general network. The monitoring of PAH is recommended.

4.1.5.3 *Metallic pollutants*

It is recommended to continue the monitoring of the metallic pollutants as currently laid out in the directives of the EU. Nevertheless, studies at the superregions may address the toxicity and health effect of these metals and their species and may use elemental composition for source apportionment.

4.2 Ambient air quality monitoring

4.2.1 Objectives

Various networks of ambient air quality monitoring sites are operated in the EU 25 addressing different environmental aspects. This part of the report shall

- identify the networks with highest relevance for the assessment of health impacts
- analyse whether these networks fulfil the criteria for monitoring population exposure, and, in case limitations are identified,
- give recommendations to improve the situation

4.2.2 Overview on air quality monitoring networks

Air quality monitoring is carried out using networks of monitoring sites. Depending on the main objective of air quality monitoring these networks comprise different numbers and types of measurement stations. Major objectives for air quality monitoring are e.g.

- the assessment of global changes to the composition of the atmosphere, reflected e.g. by the operation of clean air background stations as well as regional sites (Global Watch sites, see Figure 3)
- the assessment of transboundary transport of pollutants, being investigated by a transnational network of sites (EMEP) which are not subjected to influence of local source activities (Figure 4)
- the assessment of compliance with legal air quality standards, using a national-wide network of sites fulfilling criteria on siting, equipment and data quality laid down in the European air quality directives.

There are several cross-links between these international networks, e.g. some EMEP sites contributing also to the GAW network and the air quality assessment network.

Additional networks are operated on national, regional or municipal scale in the EU which serve to deliver air quality measurement data for particular purposes. Examples are

- national sites monitoring the regional background air quality (e.g. the UBA network in Germany),
- sites operated by municipalities to obtain information on the general air quality, e.g. as a mean to enhance attractiveness of the region for potential investors and employers,
- investigation of certain air quality parameters in regions which demand an accreditation as rehabilitation sites and being required to have particularly good air quality (e.g. climatic spas “Luftkurorte” in Germany).

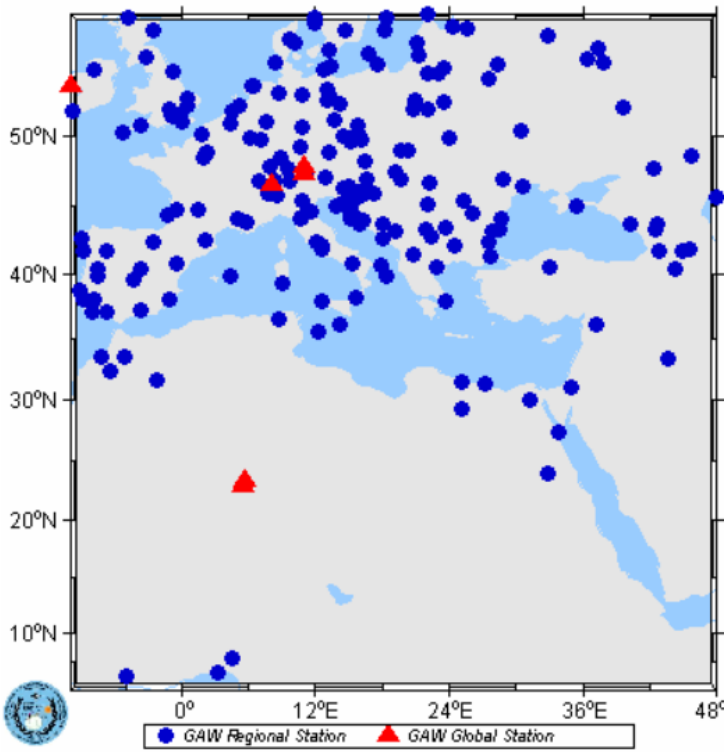


Figure 3 Air quality monitoring network of Global Atmospheric Watch (GAW)

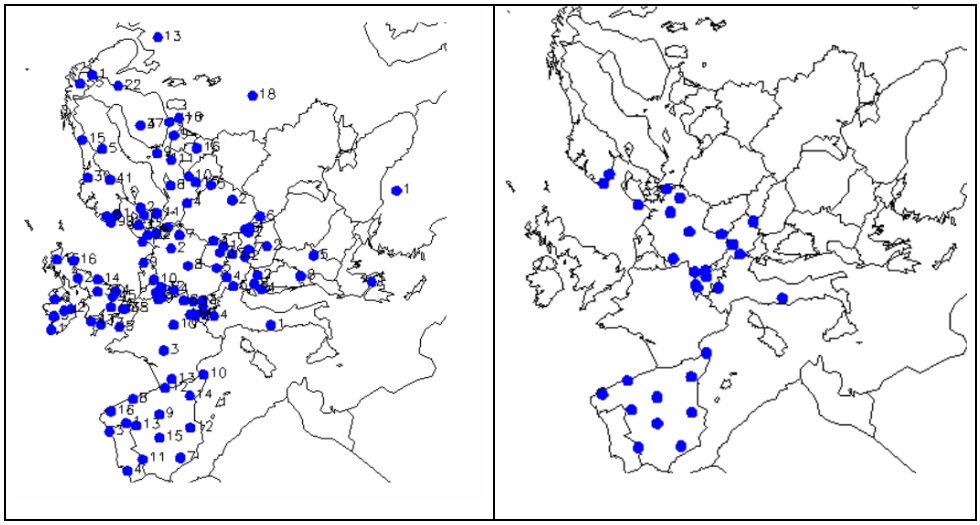


Figure 4 Air quality monitoring network of EMEP
(left: acidifying/eutrophying compounds; right: PM)

4.2.3 AirBase

Data about the several thousand measurement stations as well as measured concentrations for most relevant pollutants are stored in the Airbase database which has been established at the EEA following the requirements set in the EoI Decision [COUNCIL DECISION 97/101/EC].

According to this document, a total of 31 items on the characteristics of monitoring sites (meta data) shall be provided by the Member States. Twelve of them, shown in Table 2, are mandatory.

Table 2 Mandatory information to be provided for AirBase according to the EoI Decision

I.1	Name of network
I.4.1	Name of body responsible for the management of the network
I.4.2	Name of person responsible
I.4.3	Address of responsible body
I.4.4	Telephone and fax number
I.5	Time reference basis of the data series
II.1.1	Name of the station
II.1.4	Station code under the present Decision
II.1.8	Geographical coordinates of the station
II.1.10	List of pollutants measured
II.1.11	List of meteorological parameters measured
II.2.1	Type of area where the station is located

(table taken from [Guidance to the Annexes to the decision 97/101/EC on Exchange of Information as revised by Decision 2001/752/EC)]

Airbase meta data are available from the airbase website using a special Excel based tool. The latest meta data files correspond to the situation of 2003. These data were analysed for the number of networks (as indicated by the different network names stored in Airbase) operated in the EU 25 Member States, as shown in Table 3. Alongside, an evaluation of the distribution of measurement stations to the various networks and the number of different bodies responsible for network measurement was made.

Table 3 Number of networks and measurement stations covered by AirBase

	number of measurement stations assigned to network									
	<5	<10	<50	<100	<200	<500	>500	Total no. of networks	Total no. of stations	Organisations
AT						1		**1**	222	1
BE			1	2	2			**5**	502	5
CZ				1				**1**	71	1
DE		2	4	9	2			**17**	1018	12 *)
DK	2	1	2					**5**	40	1
EE		1						**1**	8	1
ES	34	29	36	3	1	1		**104**	1845	96
FI	20	1	2					**23**	68	22
FR	8	8	28	3				**47**	947	7
GR	7	1	1					**9**	34	7
HU	1	1	1					**3**	25	2
IE	15	2	1					**18**	74	12
IT	35	26	45	2				**108**	1249	67
LT	1		1					**2**	20	2
LU	3							**3**	5	3
LV	1		1					**2**	18	1
MT	1							**1**	1	1
NL			1	1				**2**	98	1
PL				1				**1**	52	1
PT	8	2	2					**12**	76	9
SE		1	2					**3**	43	1
SI		1						**1**	10	1
SK	1		1					**2**	45	1
UK	7		3	1	1	1		**13**	698	9
								Totals	**7169**	**254**

***) for DE Airbase reveals only 12 organisations due to assignment of networks operated in the New Länders to agencies in former Western Germany. Actually 17 bodies exist (16 Länders + UBA)**

The result clearly shows that the approaches and organisational structures for air quality monitoring vary considerably within the EU. Some (mostly smaller countries) just have one network operated by one organisation. Depending on the size of these countries the number of stations vary from <5 stations (LU, MT) to more than 200 (AT). The other extreme can be seen

for Spain and Italy where more than 100 differently named networks exist, which are operated by almost similar numbers of organisations.

The state of AirBase content is regularly assessed in EEA reports, with the latest one published in 2005 covering the state of 2003 [Mol and Hooydonk, 2005]. Accordingly, about 1,500 “phantom stations” (with no concentration data records) exist in the database and still have to be removed. There might be more misleading information in the database, as the obsolete information on the organisational structure of the German Networks shows. However, the general picture of variability and inhomogeneity between the EU Member States is probably valid.

Such variability might have consequences for the comparability and data quality in case different networks operate with different standard procedures and quality assurance procedures. In such situation good organised co-operation and standardisation between the various networks on a national and international level is absolutely essential to produce air quality data of sufficient quality and comparability.

Except the networks targeting global atmospheric change all networks mentioned above have some relation to the question of air quality impacts on human health. In case of the EMEP network the major intention is to assess the impact of gaseous pollutants on vegetation and natural resources. Nevertheless, transboundary transport of pollutants also contributes to the air quality at locations where people live and therefore concentration data measured at these sites help in the assessment of optional measures to improve air quality.

However, of the major networks the one designed for compliance checking with EU air quality standards has the most direct relation to human health, since a number of the air quality standards have been set with consideration of the health impacts associated with air pollutants.

The following sections give a brief overview of the current system of air quality monitoring in the EU according to the air quality directives and some of its features.

4.2.4 Requirements set by the air quality directives

4.2.4.1 Zoning

The current EU air quality directives demand that Member States shall assess the compliance with limit or target values in their entire territory. Because the territories may consist of areas with a large variation of orographic, meteorologic and land-use characteristics the territories are to be divided into “zones” for which the compliance with the limit values set in the directives has to be shown. In case of exceedance of limit values the Member States are obliged to develop action plans aiming at reduction of the pollution.

To facilitate the implementation of this monitoring concept and of actions plans the zone delineation largely reflects administrative boundaries (e.g. city borders, provinces).

4.2.4.2 Assessment methodologies

Principally, the assessments should be based on measurements of the considered air pollutants, but also modelling or objective estimation are methods to be applied under certain conditions. The rules set for the measurement obligations and the applicability of modelling/calculation procedures[4] as well as for the determination of the number and location of

[4] Note that only those regulations relevant for the protection of human health are considered here; the air quality directives additionally provide for the protection of ecosystems.

measurement sites are quite complex. Several criteria have to be applied, and the result is depending on

- the concentration of air pollutants as assessed for the previous 5 years,
- the type of the area (zone) for which the assessment is to be made,
- whether or not an alert value has been set for the considered air pollutants,
- the population of the zone.

With respect to the requirements on the assessment methods to be used (e.g. measurements vs. modelling) the first three parameters of the above list are relevant. AP concentrations measured or estimated in previous years have to be compared with two threshold values that are defined individually for each AP as a percentage of the respective limit value. These threshold values, termed lower assessment threshold (LAT) and upper assessment threshold (UAT) determine for each zone how the air quality assessment has to be carried out[5].

The following scheme and Table 4 illustrate this.

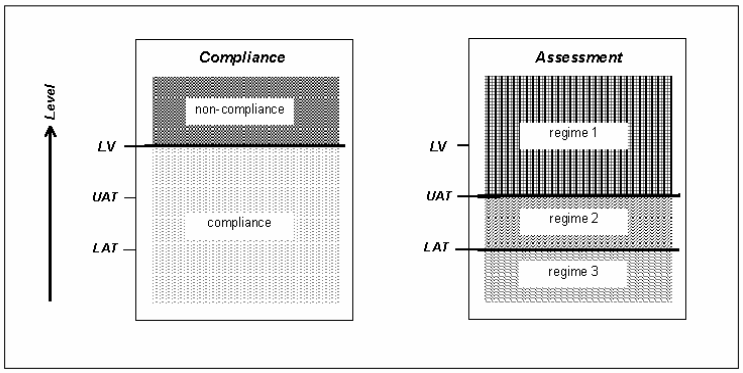


Figure 5 Illustration of the pollution level regimes relevant for methodological requirements on air quality assessment[6]

[5] It should be noted that exceedence of or compliance to limit or target values is not relevant for the assessment requirements but determines the obligation to draw up action plans and influences reporting requirements.

[6] Taken from: Guidance on assessment under the EU Air Quality Directives –Final draft; http://europa.eu.int/comm/environment/air/ambient.htm

Table 4 Methodological requirements on air quality assessment as a function of pollution level regimes[7]

Maximum pollution level in agglomeration or zone	Assessment Requirements*
Regime 1: Greater than the upper assessment threshold	High quality measurement is mandatory. Data from measurement may be supplemented by information from other sources, including air quality modelling.
Regime 2: Less than the upper assessment threshold but greater than the lower assessment threshold	Measurement is mandatory, but fewer measurements may be needed, or less intensive methods may be used, provided that measurement data are supplemented by reliable information from other sources.
Regime 3: Less than the lower assessment threshold	
a. In agglomerations, only for pollutants for which an alert threshold has been set**	At least one measuring site is required per agglomeration, combined with modelling, objective estimation, indicative measurements.
b. In non-agglomeration zones for all pollutants and in all types of zone for pollutants for which no alert threshold has been set	Modelling, objective estimation, and indicative measurements alone are sufficient.

* Data quality objectives are given in Annex VIII of the first Daughter Directive.
** In the first Daughter Directive this only applies to SO_2 and NO_2.
*** Indicative measurements are measurements using simple methods, or carried out for a restricted time. They are less accurate than continuous high quality measurement but can be used to explore air quality as a check where pollution levels are relatively low, and to supplement high quality measurement in other areas.

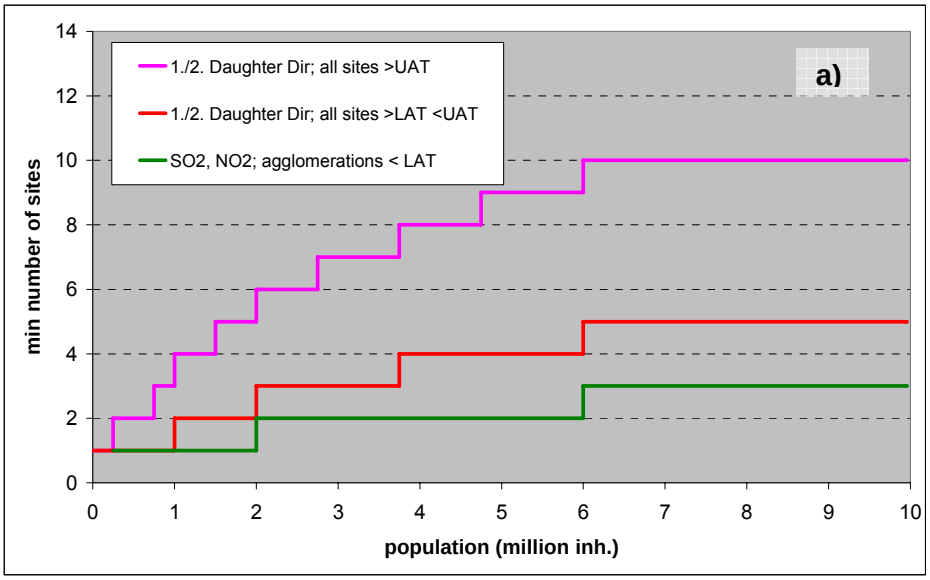
4.2.4.3 Criteria for monitoring sites

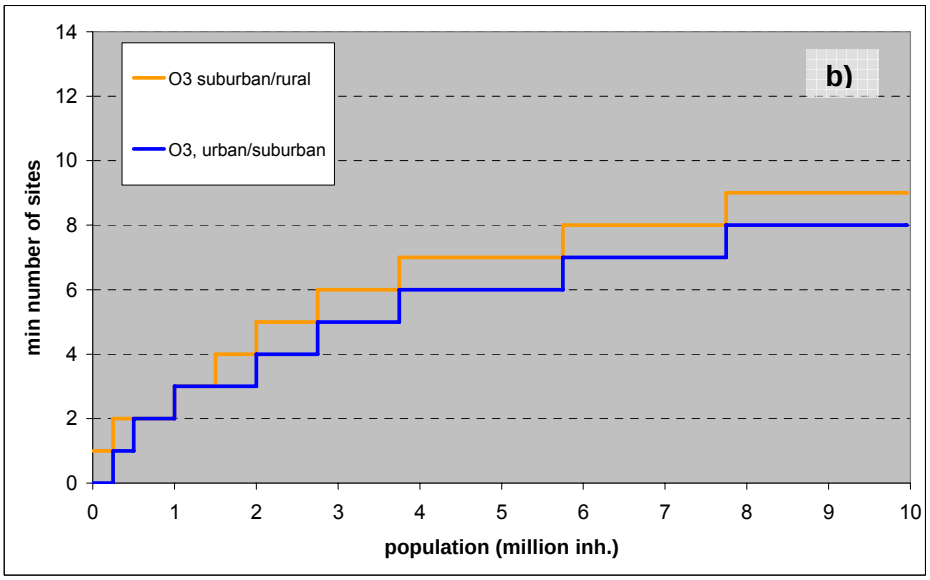
Also the number of measurement sites to be operated in each zone is governed by the three assessment regimes and in addition by the population attributed to the zone, with more sites being required when population increases. The functions applied are step-shaped, being different for the various air pollutants regulated in the daughter directives (see Figure 6).

Accordingly, for different pollutants also a different set of criteria is predominating. In the case of the air pollutants regulated in the 1st, 2nd and 4th Daughter Directives[8] the pollution level of previous years determines the number of sites. For ozone a classification of the zone with respect to its degree of urbanisation is decisive. A mixed criterion is set for SO_2 and NO_2 for which alert thresholds have been set. With respect to these pollutants measurement still is obligatory even in case of low pollution levels (< LAT) if the zone type is denoted to be an agglomeration.

[7] Final draft on Guidance on Assessment under the EU Air Quality Directives

[8] SO_2, NO_2, NOx, PM_{10}, Lead, CO, Benzene, As, Cd, Ni, B(a)P





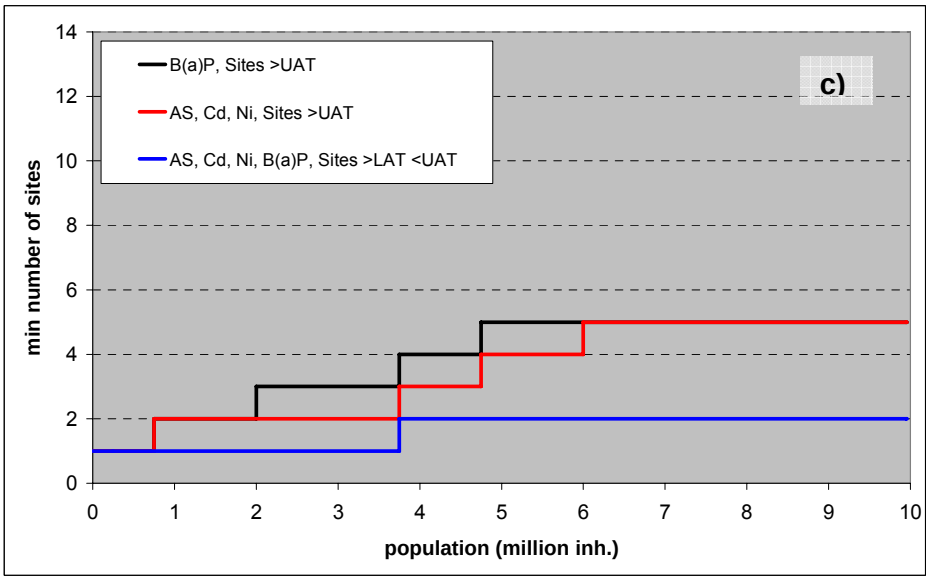


Figure 6 Minimum number of AP monitoring sites required as a function of population in assessment zones
a) 1./2. Daughter Directive b) 3. Daughter Directive c) 4. Daughter Directive

Furthermore, criteria for siting of the measurement stations are provided. With respect to the protection of human health, Member States are required to provide data on the areas with highest concentrations (hot spots) as well as on those being representative for the exposure of the general population.

No quantitative relation between these two types of monitoring sites is required or recommended, but additional requirements on representativeness are given:

Hot spot sites shall be representative of an area of at least 200 m², whereas urban background sites shall be representative for several square kilometres and shall also be representative for similar areas not in their direct vicinity.

From the information given before it can be concluded that a monitoring network is operated in accordance to the air quality directives (here considered only related to protection of human health) if

1. the number of monitoring sites equals or exceeds the minimum number laid down in the directives,
2. all required pollutants are monitored with appropriate equipment and accuracy,
3. sites are established which provide data on the highest concentrations,
4. the network comprises both, hot spot and urban background sites,
5. hot spot sites are representative for at least 200 m²,
6. urban background sites are representative for several km²,
7. urban background sites are representative for similar locations not in their vicinity,
8. and sites are established which are representative for the exposure of the general population.

4.2.5 State of the air quality directive related monitoring network in the EU Member States

4.2.5.1 Description of analysed information

When the EU air quality directives came into force the Member States had to create monitoring networks which fulfil the requirements of the directives. Information on these networks is provided by the Member States according to their reporting obligations set in article 11 of the air quality framework directive.

The Member States reports are annually submitted to the Commissions in form of Excel spreadsheets [Decision 2004/461/EC]. The reports for the year 2003 are used in this study to obtain indications for deficits and limitations with regard to health related air quality monitoring.

For these analyses the data provided in the spreadsheets have to be combined with information from Airbase, since the spreadsheets contain no data on station types or region types.

Unfortunately in case of France no assignment between the stations included in the Member States report and AirBase stations could be made since no linking entry could be found[9]. Also in other cases differences were observed, partly due to erroneous entries in one of the two databases, partly because it seems that additional stations are operated within the framework of the air quality directives which have not yet been put into Airbase.

[9] According to the requirements also the stations used for the air quality directives shall be reported with their EoI station codes.

Nevertheless, the available data were considered to be useable for the main purpose of this study and further attempts to complete the data appeared out of scope. In late 2005 a draft report particularly addressing an evaluation of the air quality questionnaire data was submitted by TNO to DG Env [vdHout, 2005]. For that report the missing links to AirBase obviously were recovered (see 6.11 Annex K: Evaluation of zoning information for further details).

Consequently, similar evaluations made in both projects were removed from this report and reference is taken in such cases to the TNO report as the more complete one. However, some additional information not covered by the TNO is still presented here. It should be kept in mind, that the data base for these analyses is somehow incomplete.

4.2.5.2 Networks related to the EU air quality directives

Table 5 compares the numbers of networks (as recorded in Airbase and assigned to the stations listed in the air quality directive spreadsheets) and stations (as recorded in the air quality directive spreadsheets and assigned to Airbase stations). With a few exceptions there are more networks and stations available in the countries than are used for the air quality directive. This might be due e.g. to different measurement objectives, as in case of clean air measurement stations.

The main conclusion to be drawn from this comparison is that the picture of high variability regarding network organisation drawn from the Airbase data is also valid for the networks operated in the framework of the air quality directives.

Table 5 Number of networks and stations used for the purposes of the EU air quality directives in comparison to data from AirBase

Country	No of networks		No of stations		
	assignable to AirBase *)	total in Airbase	AQ Directives	assignable to AirBase *)	total in Airbase
AT	1	1	183	183	222
BE	3	5	162	144	502
CZ	1	1	386	69	71
DE	16	17	457	445	1018
DK	3	5	14	12	40
EE	1	1	7	7	8
ES	47	104	350	347	1845
FI	16	23	40	39	68
FR	na*)	47	814	na*)	947
GR	6	9	29	29	34
IE	5	18	20	16	74
IT	72	108	511	468	1249
LT	2	2	16	16	20
LU	1	3	6	1	5
NL	1	2	66	48	98
PT	7	12	34	34	76
SE	3	3	67	35	45
SI	1	1	21	10	43
SK	2	2	38	25	10
UK	3	13	167	167	698
Total	191	377	3388	2095	7073

4.2.5.3 Measurement sites

By combination of the information provided in the air quality quests and Airbase it is possible to compare the number of sites of different types and surroundings used in the Member States for the air quality assessments. Such comparison is made to get information on different approaches chosen in the Member States and leads to conclusions about the comparability of the air quality assessments.

For the sake of harmonised results reference is taken here to the TNO report [vdHout, 2005] which covers similar analyses as initially done for this report on basis of the more incomplete databases obtained.

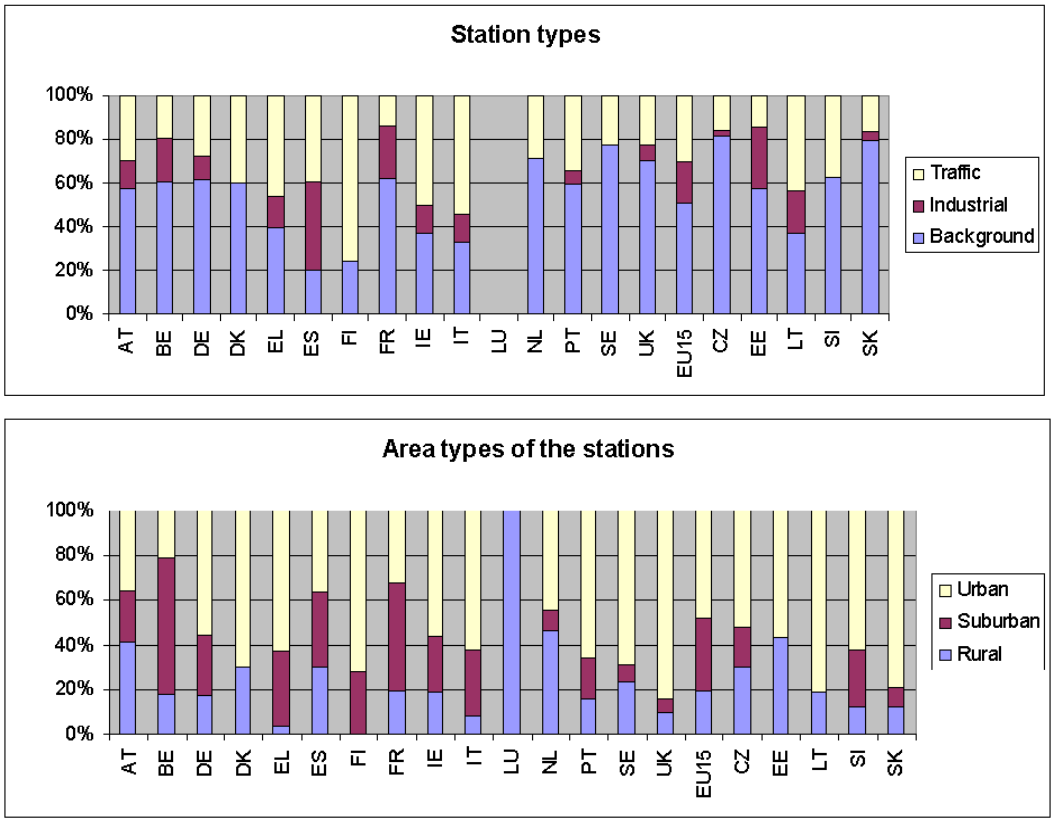


Figure 7 Station types and area types of measurement sites compiled in the air quality questionnaire (from vdHout, 2005)

In Figure 7 the distribution of station types and area types as presented in the TNO report is shown. [vdHout, 2005]. Apparently the station type distribution is quite similar in many countries with about 60% of background sites and ca 40% of traffic/industrial hot-spot sites. However, in some countries the background sites comprise a high fraction (e.g. SK 80%) and in others a low fraction (ES, IT, FI, 20-30%) of all measurement sites. To achieve better harmonisation of the approaches the proposal for the future air quality directive [COM 2005/447] requests a maximum factor of 2 between the numbers of traffic and background sites. Quite high variations are also apparent with regard to the station area. In general, urban and suburban sites predominate; a remarkable exception is Luxemburg with 100% of its sites located in rural areas. The ratio between urban and suburban sites is highly variable, on the one end of the range with

e.g. Greece having almost no suburban sites and on the other end of the range with Sweden and the UK placing less than 10% of their sites in suburban regions.

The numbers of stations with different type classification is broken down further by measured components in Table 6.

Table 6 Number of stations per pollutant and station type (2003), taken from[10] [vdHout 2005]

	Daughter directive 1	.	.	.	.	2	.	3
	Sulphur dioxide	Nitrogen dioxide	Particulate matter (<10 µm)	Particulate matter (< 2.5 µm)	Lead	Carbon monoxide	Benzene	Ozone
Reporting EU-15 countries	**14**	**14**	**14**	**8**	**6**	**14**	**11**	**14**
Total number of stations	**1665**	**2014**	**1465**	**76**	**114**	**948**	**264**	**1610**
Of which								
Traffic	388	627	473	21	54	512	152	312
Urban background	571	723	559	35	25	304	72	669
Industrial	376	276	195	1	22	74	19	160
Regional background	256	278	160	8	13	34	12	347
Other [1)]	74	110	78	11	0	24	9	122
Reporting non-EU-15 countries	**17**	**17**	**16**	**4**	**4**	**17**	**6**	**17**
Total number of stations	**322**	**302**	**213**	**15**	**46**	**115**	**25**	**186**
Of which								
Traffic	57	57	51	8	5	39	8	28
Urban background	187	172	115	6	35	54	10	82
Industrial	26	20	15	1	4	12	5	14
Regional background	52	53	32	0	2	10	2	62
Other [1)]	0	0	0	0	0	0	0	0
All countries	31	31	30	12	10	31	17	31
Total number of stations	**1987**	**2316**	**1678**	**91**	**160**	**1063**	**289**	**1796**

1) Primarily unknown.

4.2.5.4 Analysis of zoning approaches in the Member States

A comprehensive analysis on the actual state of zone delineation and zone numbers based on the official Member States reports is given in the TNO report [vdHout 2005]. Some conclusions of this report are:

- In general larger countries have more zones than smaller ones
- there is a large variation of zone areas, ranging from 0.8 to up to 338,145 km²

[10] Non EU 15 countries comprise New MS, EU Acceeding Countries, EEA Candidate Countries and EFTA countries

- some countries delineated zones to some extent dependent on the pollutant
- about one third of the total 664 zones are denoted “agglomerations”
- the agglomeration zones cover about 40-50% of population, but only 4-5% of the area
- 27% of agglomeration zones, mostly located in F, ES and I, have less than 250.000 inhabitants

For this report, some additional analyses on the relation between zone type (agglomeration/non-agglomeration) and the population density has been made. Details on this work can be found in chapter 6.11 Annex K: Evaluation of zoning information. The analysis covers 19 of the 20 countries which submitted reports, since Germany did not report area and population data. The main result is presented in Figure 8 which shows a bimodal distribution of population density representing the non-agglomeration and agglomeration zones, respectively. While the principle shape of the distribution is as expected there is a considerable overlap between the distributions. A closer look at those non-agglomeration zones with population densities higher than 1000 inhabitants/km² reveals that most of these zones have populations below 250,000 and thus are not required by the air quality directives to be classified as agglomerations. This means that member state authorities have somehow inconsistent criteria for the assignment of a zone to the zone types. Particularly denoting zones with high population density as “non-agglomeration” might be problematic, because this could in principle cause less attention to the air quality situation.

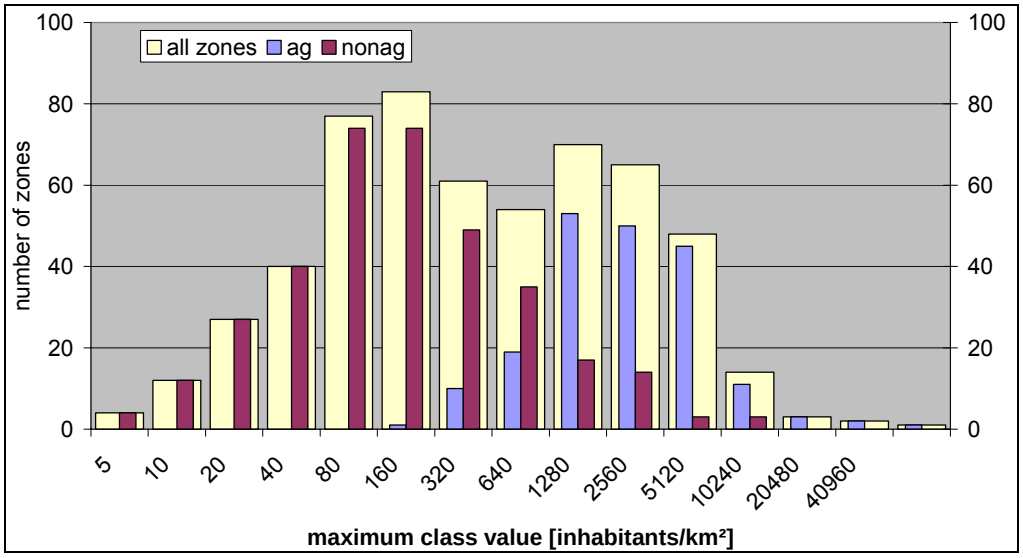


Figure 8 Frequency distribution of population density of the air quality zones

The apparent different zoning approaches might further influence the comparability of air quality assessments between different countries and should at least be taken into account if conclusions are drawn with respect to the classification of zones as agglomerates and non-agglomerates.

4.2.5.5 Area and population represented by the monitoring sites

As requested by the air quality directives the measurement sites have to be representative for certain areas, depending on their function to monitor background or hot spot concentrations. No

quantitative value is given in the air quality directives for the area of representativeness. However, some indication can be obtained from an EEA paper [Larssen et al., 1999]

Table 7 Areas of representativeness (radius of area) for various station classes[11]

Station class	Radius of area
Traffic stations	*)
Industrial stations	10-100 m
Background stations:	
- Urban background stations	100m-1 km
- Near-city background stations	1-5 km
- Regional stations	25-150 km
- Remote stations	200-500 km

Using such figures the overall area represented by the sites in a given zone can be calculated and compared with the zone area. Furthermore, also the fraction of the population represented by the monitoring sites can be estimated using the average population density in the zone.

From the air quality questionnaire information on the number of monitoring stations in a zone, its area and on the total population living there is available. Information on the type of station and area type can be obtained from the AirBase database.

Using the information on site characteristic and assumed represented areas the total area represented by the air quality measurement sites in the considered countries can be estimated. To obtain an estimate on the population represented by the sites additional weighing factors were used to model the variable population density in the surrounding of the different station types. (For details on the approach used see chapter 6.12 Annex L: Types of sites and represented area and population).

Within the limitations given by the chosen approach it can be concluded that in general the number of measurement sites used for the air quality assessments covers only a quite small fraction of the zone areas and is not sufficient to obtain data on the exposure of the majority of the people living in each of the assessment zones.

However, these results should be considered to be indicative only due to the estimation based approach of the model applied. There are two weak points in such analysis:

1. the areas of representativeness as shown in Table 7 are likely to be derived on expert judgement only and thus are quite uncertain
2. only average population density for the entire zone could be calculated and the assumptions made for the different population density in the vicinity of different measurement locations might be wrong.

Nevertheless such evaluation is considered useful to get an impression how the representativeness of measurement sites could be assessed and which information must be gathered to achieve a more realistic basis for such assessment. This aspect is discussed in the next chapter.

[11] Range of values taken from Larssen, 1999

4.2.6 Case studies on area representativeness

4.2.6.1 Ruhr District agglomeration

As concluded from the analyses presented in the previous chapter the indicative values for the area of representativeness (AoR) assigned to station types do not seem to be sufficient to give a realistic picture on the representativeness of air quality measurements made. It is obvious, that the area of representativeness will not be a constant for a given station type nor for a particular site, because it depends

- on the variations of source strengths, Topography, meteorological conditions in the surrounding area
- the pollutant under consideration
- time variance of pollution concentrations
- acceptable site-to site differences.

To illustrate this, an evaluation was made using data from background stations located in the highly populated Ruhr District, which approximately covers an area 100 km × 30 km (Figure 9). Besides population related sources (domestic burning, traffic) there are also industrial sources, in particular iron& steel and non-ferrous metal industries which are predominantly located in the western part of the Ruhr District.

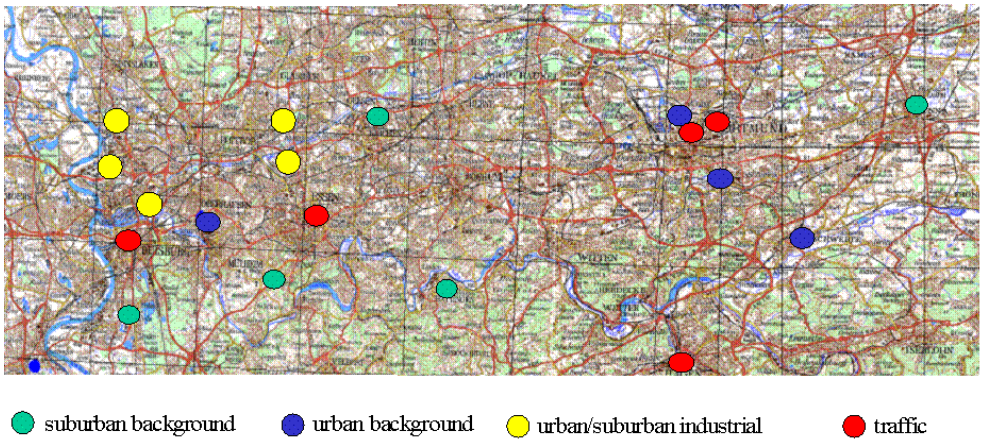


Figure 9 Map of the Ruhr District with locations of some air quality monitoring sites operated by the State Environment Agency (LUA)

Using the indicative area of representativeness values from [Larssen et al, 1999] the measurement stations shown in Figure 9 would be representative for a maximum area of ca. 400 km², thus covering only a bit more than 10% of the entire area. Applying the radius for suburban background stations of 5 km to all urban/suburban sites (excluding traffic sites) the coverage would increase to ca 30% (ca. 1,100 km²).

To obtain illustrating information on the representativeness of the Ruhr District sites shown in Figure 9 the measurement data for PM_{10} (Table 8) and NO_2 (Table 9) were analysed statistically. The results are further displayed in Figure 10.

Table 8 Statistical evaluation of Ruhr-District PM10-data per station type for 2004 upper part: annual mean, lower part: number of limit value exceeding days; data taken from [LUA, 2004]

PM10		SUB	UB	IND	SUB/UB/IND	Traffic
annual	mean	25.3	25.5	30.0	26.7	31.4
µg/m³	Std-Dev %	8.8	6.2	2.7	10.1	21.1
	min	22	24	29	22	24
	max	27	28	31	31	42
	Max-min	5	4	2	9	18
	% of mean	20	16	7	34	57

PM10	mean	19	24	38	26	42
days	Std-Dev %	31.1	41.4	25.1	42.4	76.4
>50 µg/m³	min	13	12	25	12	15
	max	26	35	48	48	97
	Max-min	13	23	23	36	82
	% of mean	67	96	61	137	195

Table 9 Statistical evaluation of Ruhr-District NO_2-data per station type for 2004 upper part: annual mean, lower part: maximum 1-h-values; data taken from [LUA, 2004]

NO2		SUB	UB	IND	SUB/UB/IND	Traffic
annual	mean	32.0	33.0	32	32.3	46.8
µg/m³	Std-Dev %	9.9	5.5	5.7	6.8	19.9
	min	28	31	30	28	40
	max	34	35	34	35	63
	Max-min	6	4	4	7	23
	% of mean	19	12	13	22	49

NO2	mean	128	146	149	141	170
1 h max.	Std-Dev %	15.0	22.8	24.6	20.8	29.2
µg/m³	min	100	113	113	100	132
	max	137	191	200	200	255
	Max-min	37	78	87	100	123
	% of mean	29	54	58	71	72

From the results obtained it can be concluded that in case of the annual mean for PM10 each of the subsets of stations would be sufficient to describe the situation at the other locations without large errors. Even traffic stations are quite comparable with regard to both, mean value and variance.

The situation is more variable in case of the days exceeding the actual limit value for PM10. Clearly, hot-spot sites influenced by traffic or industrial sources have a higher probability for such events than background stations. Nevertheless, differences among the background stations are quite low and again each of the subsets would be sufficient.

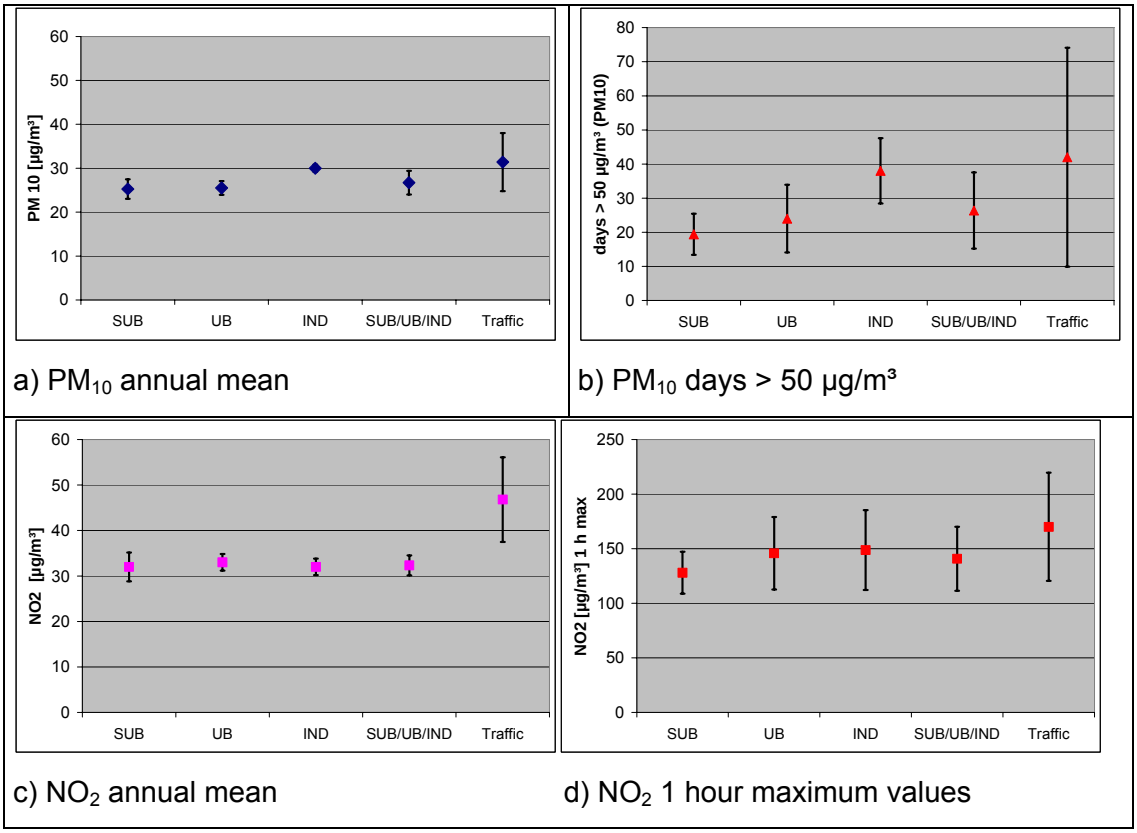


Figure 10 Graphical display of averages and standard deviations of data shown in Table 8 and Table 9

In case of NO_2 it is remarkable that the average 1 hour maximum values found at the traffic sites fits well to the corresponding background station values. On the contrary, there is a clear split between background stations and traffic station when looking at the annual mean. However, also in case of NO_2 the variability between the subsets of background sites is low and thus both, the annual mean NO_2 concentration and the 1 hour maximum values in the Ruhr District could be characterised with less monitoring sites.

In conclusion it can be stated that in a dense and quite homogeneous agglomeration background monitoring sites may have a remarkably high area of representativeness with respect to PM10 and NO_2. Considering that about well placed 5 stations would be sufficient to obtain a reliable estimate for concentration distribution in the entire area, the area of representativeness can be estimated to be in the range of 500-600 km².

Clearly, any approach assigning a fixed area of representativeness to a measurement station seems to be highly dependent on the methodology of evaluation. In the next chapter additional limitations and counter-arguments will be identified by looking in detail at a more inhomogeneous area.

4.2.6.2 Duisburg source apportionment study

In the previous chapter it was shown that the variation of PM10 concentrations in between urban background monitoring sites in the Ruhr District are comparably low. Following, the western part of the Ruhr District is looked at in more detail using data obtained within a comprehensive source apportionment study carried in the region of Duisburg (Quass et al., 2004).

Figure 11 shows the site locations of three urban/suburban background sites where daily PM10 samples were collected and analysed for their composition.

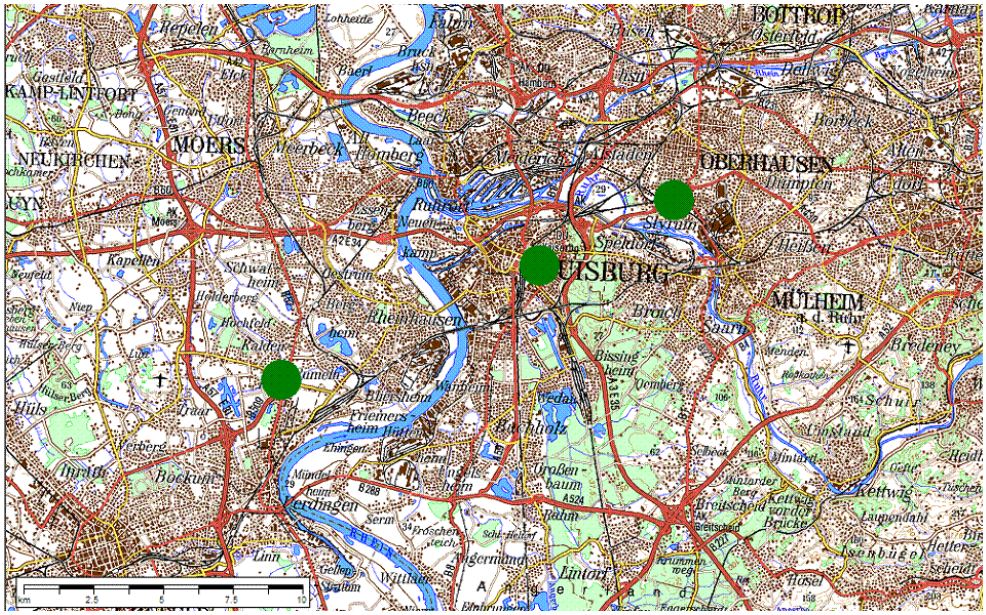


Figure 11 Map of the three urban background sites, airline distance from most western to eastern station about 16 km

Figure 12 shows that the correlations of PM_{10} and $PM_{2.5}$ mass concentrations between the three urban background sites were excellent (coming close to the requirements as laid out for equivalence of two PM_{10} samplers in EN 12341). Hence the findings of the analyses made for the entire Ruhr District area is confirmed.

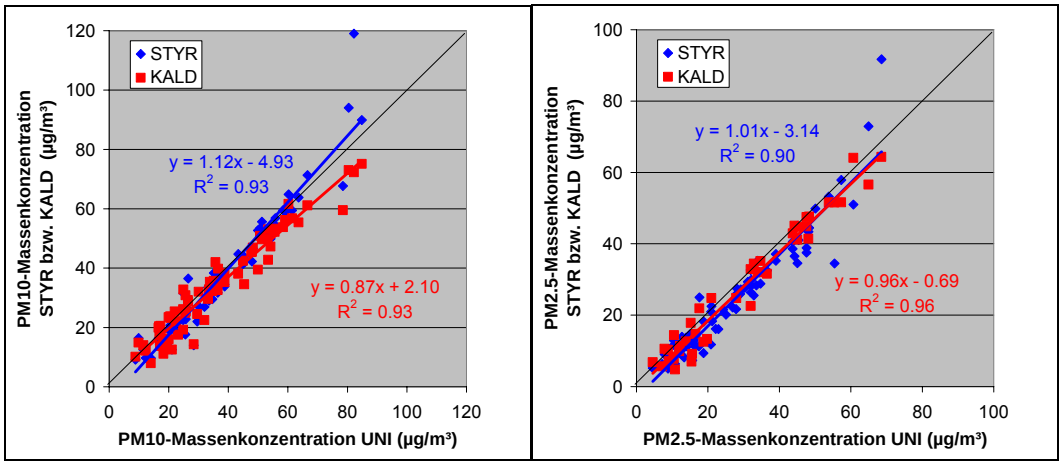


Figure 12 Correlation analysis of discontinuous PM_{10} and $PM_{2.5}$ 24 hour average mass concentrations (UNI vs. STYR/KALD)

In Figure 13 a similar correlation analysis is shown but this time for the PM_{10} constituents sulphate, nitrate and iron oxide (discontinuous, 24 h average). The correlations for the main PM_{10} constituents, sulphate and nitrate (secondary particles), are very good. This can be explained by their sources (SO_2, NO_X) being more regional leading to relatively low spatial variability.

The correlation significantly decreases if minor PM_{10} constituents of more local origin (here mainly > 1 µm d_{ae}) are investigated. This is exemplarily shown in Figure 13 by the example of iron oxide.

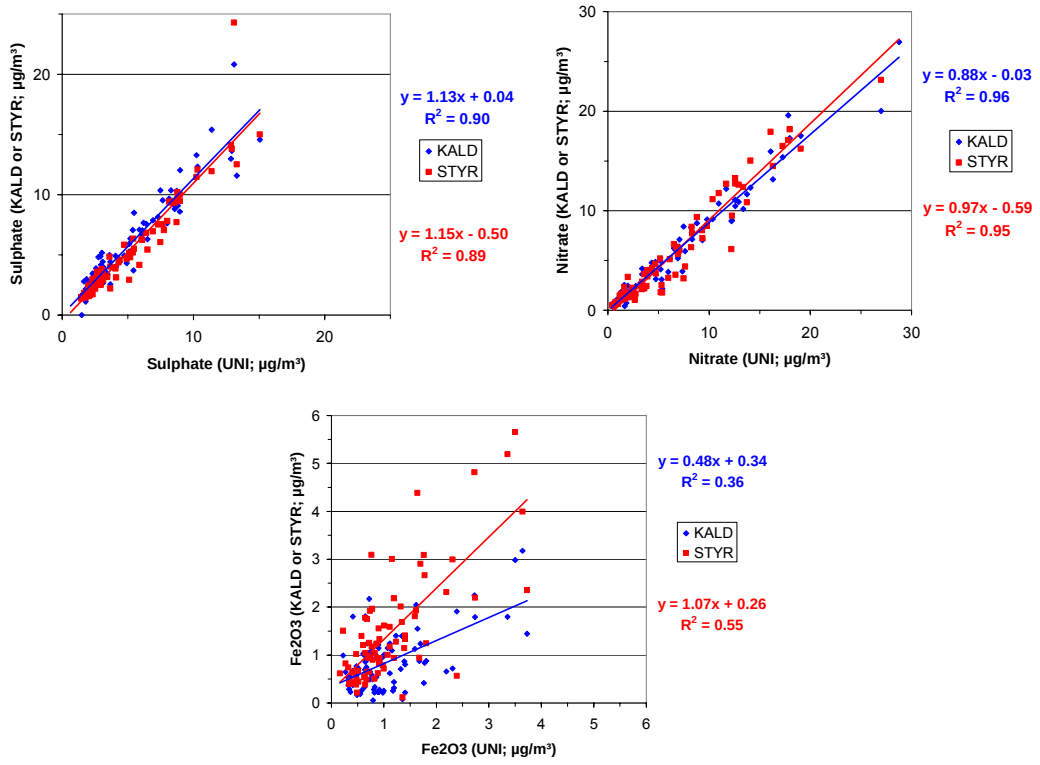


Figure 13 Correlation analysis of PM_{10} constituents sulphate, nitrate, and iron oxide

This observation can also be made for other trace compounds including the health relevant ones being regulated in the 4th DD (Figure 14). This largely reflects the influence of local pollution sources. Such considerable industrial influence can also be seen in PM10 measurement values obtained at measurement sites in the near surroundings of the background stations where the campaigns took place (Figure 15).

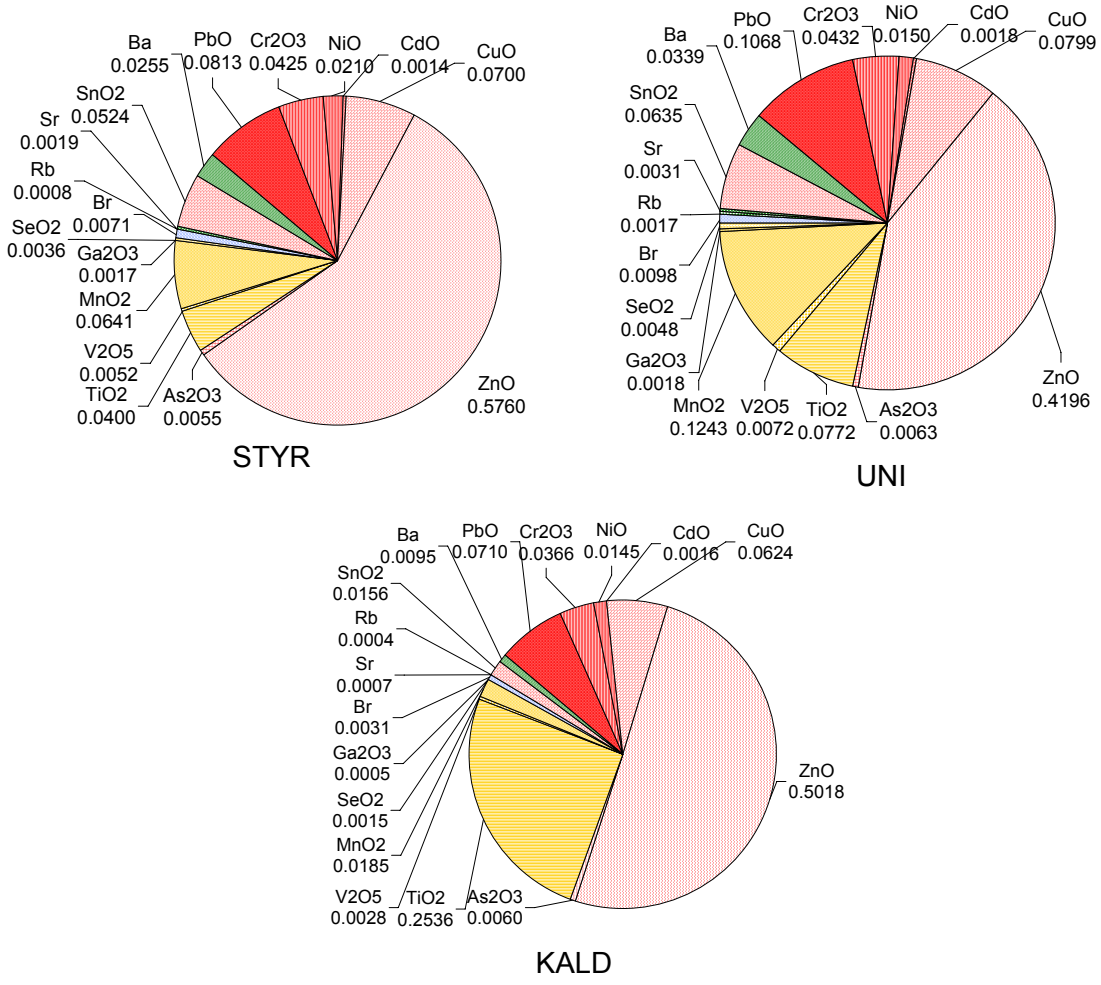


Figure 14 Mass-% of trace elements in PM_{10} at the three sites

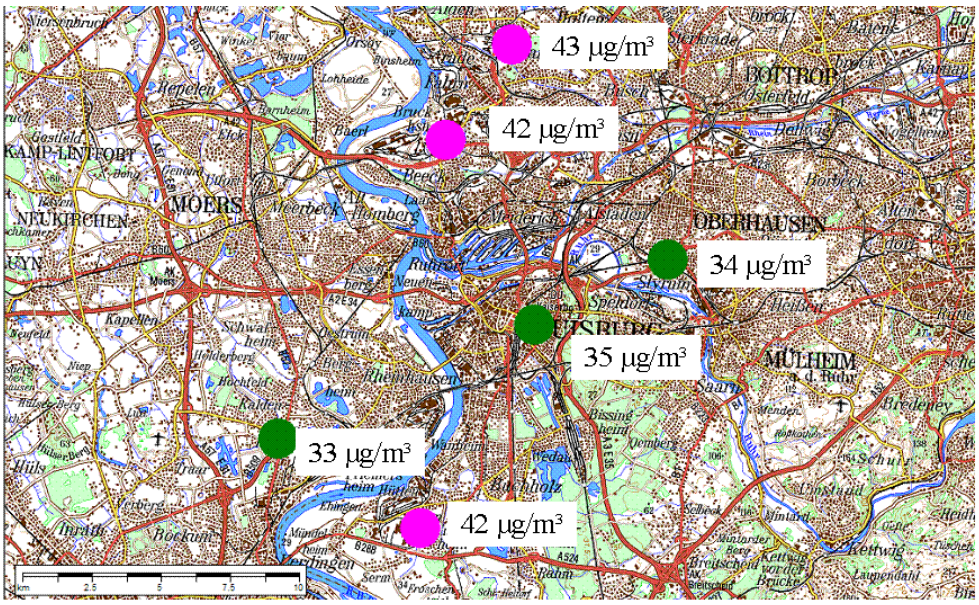


Figure 15 Spatial differences in PM_{10} mass concentration in the investigated area

In conclusion, any application of a standard area of representativeness to a particular site must be done with caution and clearly must take into account the pollutant and its distribution characteristics.

Further care must be taken with respect to the air quality data used for studies of short/long term health effects. Therefore, in the following Figure 16 measurement PM10 data comparison between 2 urban background sites with different averaging intervals (30 min, 8 hours, 24 hours) are shown. From this brief study it can be concluded that the comparability of the measurements and hence the area of representativeness goes down with decreasing averaging intervals.

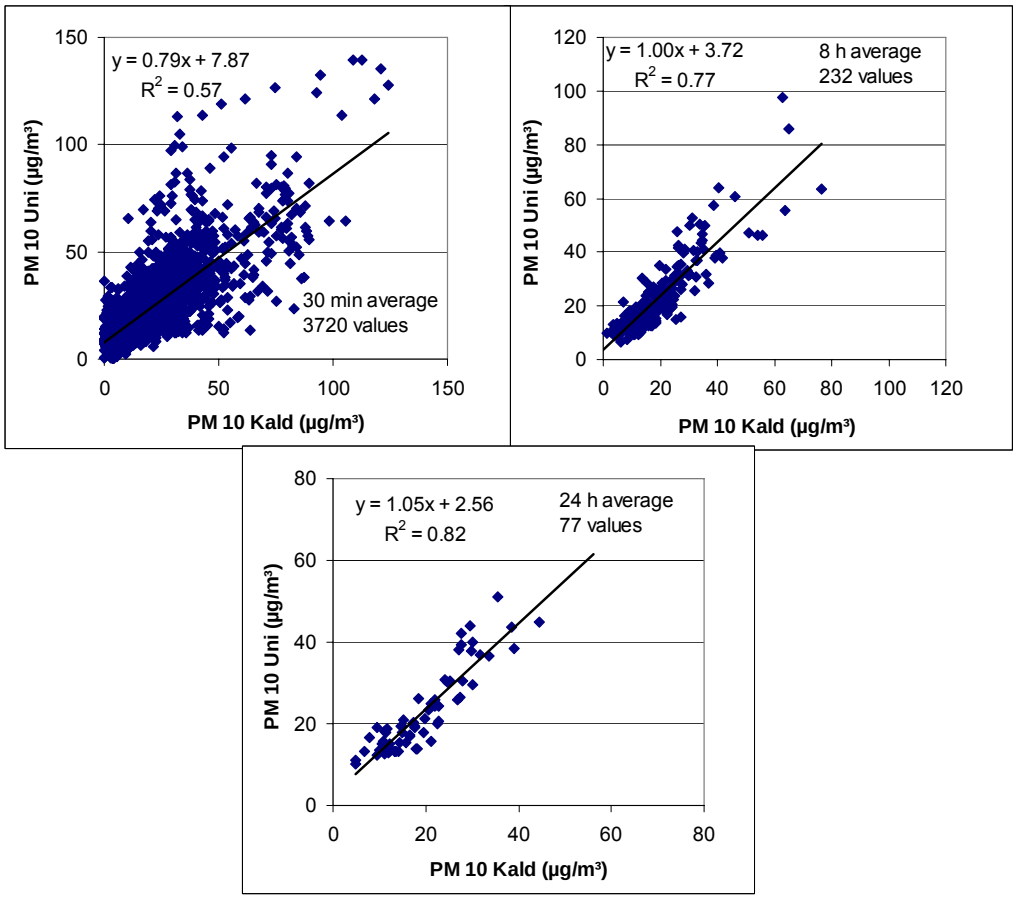


Figure 16 Correlation of PM10 data at different averaging intervals

The results of the case studies thus again stress the importance to develop procedures for an accurate assignment of station types and of representativeness regarding area and population exposure.

Guideline on principle approaches available for this purpose has been formulated in the air quality directive guidance paper[12]. Still, these guidelines contain no recipe that could be applied universally.

[12] http://europa.eu.int/comm/environment/air/ambient.htm

4.2.7 Conclusions air quality monitoring

From the analyses and considerations presented before the following main conclusions can be drawn:

- The analysis of network and station type composition in the Member States reveal several factors which are likely to adversely affect the overall air quality data quality and comparability:
  Still, there is a considerable divergence in the structure of individual Member States networks. The different philosophy, being explainable by different history and different national legislation, is obvious from the large range of network numbers (between 1 and ~100) operated in the individual Member States. Also, the partly inconsistent classification of zones as agglomerations and non-agglomerations indicates different assessments of the pollution situation in the Member States. The most severe result of this different historical background is that in some countries the focus is more on those sites with highest pollution near local sources whereas in other Member States monitoring in living areas in the urban and suburban background predominates[13].
- With respect to health effect related monitoring there are several major limitations in the current air quality assessment:
- Neither the area of representativeness nor assignment of represented population to the stations is available. In the Airbase database areas of representativeness (AoR) are given only for comparatively small number of stations, with considerable implausibilities.
  Application of the indicative values for the concentric area of representativeness to the stations used within the framework of the air quality directive does not lead to any meaningful result. Exemplary analyses made for measurement stations in the Ruhr District agglomeration on the one hand show a high comparability of background stations with regard to PM10 and NO_2 annual mean values, which would lead to large average area of representativeness per station. On the other hand it can be clearly shown that the area of representativeness might be lower than expected if sites being influenced by local sources are found nearby. Thus the concept of assigning a concentric area of representativeness to station types must be questioned and should be given up.
- On basis of the given data stored in Airbase or reported by the Member States under the air quality directive an assessment of population exposure, which is the essential input for health effect assessment, cannot be made with sufficient accuracy and spatial resolution.

Hence, the major conclusion to be drawn from the analysis of the current state regarding ambient air monitoring is the urgent need to develop a scientific sound but still practicable methodology for determining the optimal points for measurement stations in order to generate representative population exposure values. In the related documents prepared by EEA or the Commission a number of principle approaches can be found which will be taken up and further developed in chapter 5.

[13] This issue has already been taken up in the proposal for the future new air quality directive which requests a maximum factor of 2 between the numbers of traffic and background sites.

4.3 Health Status Monitoring

In the following chapter we will focus on the current status of health status monitoring within the EU and Member States. Air pollution health effects are not assessed routinely by any body or agency within EU. But data is available or could be made available by Member States so that these data could form the basis for epidemiological studies or health impact assessment. Therefore, the focus of this chapter is to summarize the current status of different data sources that could or are providing routine data on health status of populations.

In order to evaluate the short-term health effects of ambient air pollution time-series of health status data are frequently used. Temporal health status monitoring can provide data bases to perform these studies. The availability of these data within Member States has been investigated in a survey and is described in detail below.

In order to evaluate the long-term or chronic health effects of air pollution cohort data is needed to adequately adjust for individual risk factors. Routine monitoring of health status/survival in cohorts is not feasible/adequate and will therefore not be considered in this chapter.

However, spatial health status monitoring is needed to perform health impact assessment. These data are assembled by the same bodies as the temporal health status data, but are highly aggregated with respect to time, such as yearly admission rates for a disease category, but often have more additional information, such as yearly admission rates for a disease category by sex and 5 year age-groups.

4.3.1 Temporal health status monitoring

Background

Temporal health status monitoring comprises recording of health endpoints relevant to short-term air pollution health effects. This data is needed in epidemiological studies to assess the magnitude of acute health effects associated with daily changes in ambient air pollution exposures.

The EU has established a statistical database, EUROSTAT, Statistical Office of the European Communities, in 1953. Its mission is to gather and analyze figures from the different European statistics offices in order to provide comparable and harmonized data to the European Institutions so they can define, implement and analyze Community policies. The data cover the European Union, its Member States and its partners, and are published under a variety of Themes and Collections. Daily health status monitoring data is not available at EUROSTAT. EUROSTAT provides health data temporarily more aggregated only.

The WHO Europe established a database called European health for all database (HFA-DB) (http://data.euro.who.int/hfadb/) that contains data on about 600 health indicators collected from national counterparts in 52 European countries and also includes data from other WHO technical programmes and some international organizations.

Furthermore several EU and other projects work on establishing common definitions for health outcomes and databases. A summary of these projects is provided in Annex 6.4. For example in the APHEIS framework guidelines for the routine health status monitoring for air pollution epidemiology have been proposed (Annex 6.5) and the feasibility of an epidemiological surveillance system was assessed. APHEIS reported a delay of 1 month to 4 years with a median delay of 1.6 years for mortality data. Availability of individual data was restricted in most centers as a result of existing national laws on access to personal data. The median delay for hospitalization data was 12 months and not all centers were able to provide all endpoints (APHEIS I report pages 95-98). The APHEIS team concluded that health and demographic data

management tends to involve different levels, local as well as regional and national. They state that there is a varying institutional involvement in data availability, analysis and dissemination, with each agency tending to preserve its role. There was the necessity of essential human and structural resources to support a surveillance system to be generally available at the time of the survey.

Survey of available data within Member States

We selected the following health outcomes which may be recorded by surveillance systems. The selection was based on the current knowledge and feasibility aspects:

- Daily counts of cause-specific mortality
- Daily counts of cause-specific hospital admissions for adults and children
- Respiratory health in children: asthma attacks, respiratory symptoms, restricted activity, medication use, emergency room visits

For this report we evaluated whether this data is monitored in Europe.

Based on the APHEIS recommendations and experience documented in its reports we designed a questionnaire that was sent to Statistics Institutes and Public Health Institutes of the Member States to inquire the availability on routine health outcome data on a daily level. Email addresses were obtained mainly through internet research and data from the APHEIS report. Questionnaires were sent to further addresses, when provided by the national institutions in their answers.

The questionnaire asked on availability of mortality, hospitalization, children respiratory health, influenza epidemics data on a daily level (see Annex 6.6). Additionally we designed a questionnaire to be sent to scientists of the broad field of air pollution epidemiology in all Member States (see Annex 6.7). The following table summarizes the data availability on Member States level as a result of the questionnaire.

Table 10 Health status data availabilty on Member States level (questionnaire)

	Mortality data			*Hospitalisation data*			*children respiratory health data*			*Influenza data*		
Country	*Name of Institution*	*daily basis*	*routinely*	*Name of Institution*	*daily basis*	*routinely*	*Name of Institution*	*daily basis*	*routinely*	*Name of Institution*	*daily basis*	*routinely*
Austria	STATISTIK AUSTRIA	y	y		no	N/A		no	N/A		no	N/A
Belgium	SCIENTIFIC INSTITUTE OF PUBLIC HEALTH	y	y	SPF Sécurité sociale	y	no		m	m	National Influenza Centre	y	y
Cyprus	Statistical Service of Cyprus	y	y	Statistical Service of Cyprus	y	y	Statistical Service of Cyprus	y	y	Statistical Service of Cyprus	y	y
Czech Republic	Czech Statistical office	y	y	Institute of Health Information and Statistics	y	y	National Institute of Public Health	y	y	National Institute of Public Health	y	y
Denmark	Statistics Denmark	y	y	Statistics Denmark	y	.		m	N/A	Statens Serum Institut	y	m
Estonia	Statistics Estonia	y	y		no	N/A	Health Protection Inspectorate	y	m	Health Protection Inspectorate	y	m

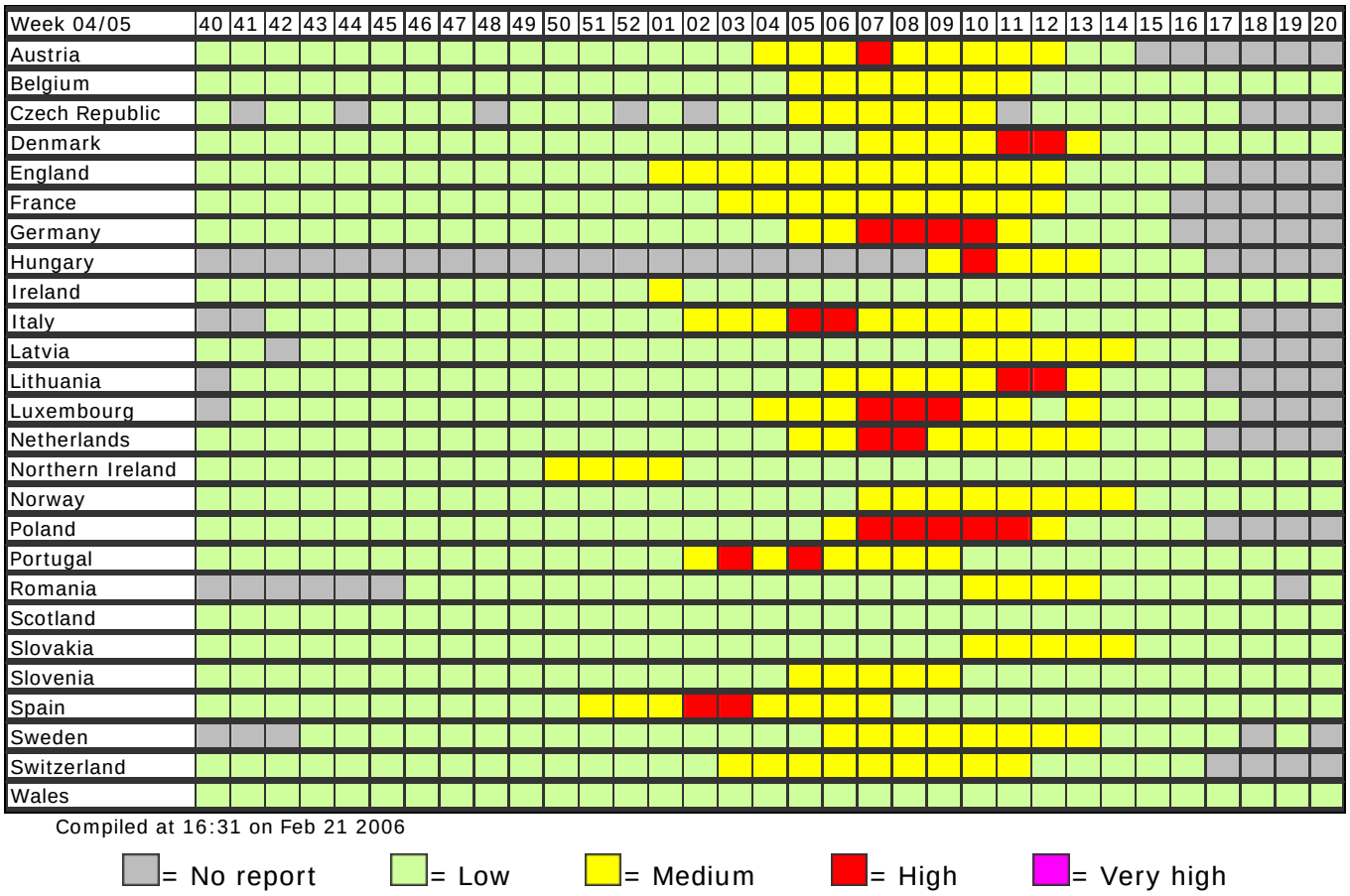
	Mortality data			Hospitalisation data			children respiratory health data			Influenza data		
Country	Name of Institution	daily basis	routinely	Name of Institution	daily basis	routinely	Name of Institution	daily basis	routinely	Name of Institution	daily basis	routinely
Finland	Statistics Finland	y	y	National Research and Development Centre for Welfare and Health	y	y		no	N/A	National Public Health Institute	y	y
France	InVS	y	y	InVS	y	no	GROG	y	m	GROG Open Rome	y	m
Germany	Statistischen Landesämter der Länder (16x)	y	y	Federal Statistical Office Germany	.	no	Federal Statistical Office Germany	.	no	Abteilung für Infektionsepidemiologie - Robert-Koch-Institut	y	y
Greece		m	m		m	m		m	m		m	m
Hungary		m	m		m	m		m	m		m	m
Ireland	Central Statistics Office	y	no	Department of Health and Children	y	y		no	N/A		no	N/A
Italy	ISTAT – National Institute of Statistics	y	y	Ministry of Health	y	y	Ministry of Health	m	m	Ministry of Health	m	m
Latvia	Health statistics and medical technologies state a	y	y	Health statistics and medical technologies state agency	y	y	Health statistics and medical technologies state agency	y	y	Health statistics and medical technologies state agency	y	y
Lithuania	Statistics Lithuania	y	y	Lithuanian Health Information Centre	no	N/A		no	N/A	Centre for communicable diseases prevention and control	y	no
Luxembourg	Direction de la Santé	y	y		no	N/A		no	N/A	Laboratoire National de la Santé – Laboratoire de Virologie	y	y
Malta	Department of Health	y	y	Data Management Unit, St. Luke's Hospital	y	y	Data Management Unit, St. Luke's Hospital	y	y	DISEASE SURVEILLANCE UNIT, DEPARTMENT OF PUBLIC HEALTH	y	y
Norway	Statistics Norway, Division for Health Statistics	y	y	Statistics Norway, Division for Health Statistics	y	y		no	N/A	Norwgian Institute of Public Health	y	y
Poland	CENTRAL STATISTICAL OFFICE of POLAND	y	y	Medical Statistics - National Institute of Hygiene	y	y		no	N/A	National Influenza Center - National Institute of Hygiene	y	y
Portugal		m	m		m	m		m	m		m	m

Country	Mortality data			Hospitalisation data			children respiratory health data			Influenza data		
	Name of Institution	daily basis	routinely	Name of Institution	daily basis	routinely	Name of Institution	daily basis	routinely	Name of Institution	daily basis	routinely
Romania	Medical Documentation and Sanitary Statistics Cent	m	m		m	m		m	m		m	m
Slovenia	Ministry of the Interior	y	y	Institute of Public Health	y	y		no	N/A		y	y
Slovak Republic	Statistical Office of the Slovak Republic	y	y		m	m		m	m		m	m
Spain		m	m		m	m		m	m		m	m
Sweden	National Board of Health and Welfare Centre for Ep	y	y	National Board of Health and Welfare	y	y		m	m	Smittskyddsinstitutet	y	m
Switzerland	Swiss Federal Statistical Office	y	no	Swiss Federal Statistical Office	y	no		no	m	Swiss Federal Office of Public Health	y	y
The Netherlands		m	m		m	m		m	m		m	m
United Kingdom		m	m		m	m		m	m		m	m

m: missing, y: yes

Health data as required for health effect monitoring of air pollution is not available on EU level but mostly from national or sometimes from regional institutions. With respect to data delivery in some states privacy laws have to be considered that may allow usage of data on this low aggregation level only under certain circumstances. In addition, it is unclear how complete the information from the state agencies was. So, there seems to be the possibility that additional data sources may exist. For example, the survey showed that influenza data is only recorded on weekly basis. However, weekly national influenza data is available from the European Influenza Surveillance Scheme (www.eiss.org) for many EU Member States since 2001 (example Table 11. The complete list of institutions and contact persons is included in Annex 6.8 (Information gathered by the questionnaire on health data availability).

Table 11 Example EISS Reports; Influenza intensity for season 2004/2005



Experience of the APHEA studies as well as the APHEIS and other projects showed that data quality with respect to completeness as well as comparability of mortality data is better than hospitalization data throughout Europe. The projects on establishing common definitions for health outcomes and databases in Annex 6.4 = D “Projects on health indicators” aim at improving the data quality in this respect throughout Europe.

4.3.2 Spatial health status monitoring

There are two main areas with respect to health effect and impact assessment of air pollution where spatial health status monitoring is needed.

First, it can be used in epidemiological multi-centers to adjust for effect modification due to different overall health status or population composition.

Second, it can be used for health impact assessment. Here mainly the distribution of the population at risk and the frequency of the outcomes are needed. These data are required on the same regional level as the different air pollution categories.

We assessed the availability in the EUROSTAT database on annual data on:

- Population indicators
- Health indicators
- Optional indicators
- Geographic indicators

EUROSTAT has data on most but not all of the indicators of interest, as shown inTable 12. For some items the spatial resolution maybe too low. The spatial resolution needed is given by the population representative air pollution categories. No data on respiratory disease prevalence is available.

Table 12 Overview of spatial health data available at Eurostat

Yearly data for HIA	Parameter	Name of the EUROSTAT table	Description	spatial resolution	note	path
Population indicators	Population of the study area by sex and age in 5 year groups	XD2JAN	Population at 1st January by sex and age - Non-EU25 Countries	1/301		General and regional statistics/regions/demographic statistics/
		D2JAN	Population at 1st January by sex and age	1/426		General and regional statistics/regions/demographic statistics/
		SCD_I (DE1001I Total Resident Population)	Indicators for sub-city districts at 2 levels	5940 geopolitical entities	no age classes	General and regional statistics /urban audit
		CITY_V	Variables for core city and 'Kernel' plus national data	314 Cities		General and regional statistics /urban audit
	% of persons over 65 years of age	XD2JAN/D2JAN	see above			
	Educational level	SCD_I (TE2016I Proportion of resident population qualified at level 1 …)	Indicators for sub-city districts at 2 levels	5940 geopolitical entities	many missing values	General and regional statistics /urban audit
	Unemployment rates	SCD_I (EC1020I Unemployment rate)	Indicators for sub-city districts at 2 levels	5940 geopolitical entities	many missing values	General and regional statistics /urban audit
		Labour force survey=LFS (e.g. LFS regional series : UN3RT)	Unemployment rates by sex and age, at NUTS level 3	many tables on NUTS 1,2,3 level	by age and sex	
		CITY_V	Variables for core city and 'Kernel' plus national data	314 Cities	by age and sex	General and regional statistics /urban audit
	Poverty rates	CITY_V	Variables for core city and 'Kernel' plus national data	314 Cities	by age and sex	General and regional statistics /urban audit
		Several tables with different indicators by sex and age		36 countries		Population and Social conditions / Living conditions and welfare / Income and living conditions / Monetary (income) poverty
	Smoking prevalence by sex and age in 5 year groups	HLTH_LS_CGSMKE =	Smokers by number of cigarettes, by sex, age and educational level (%)	10 Year age classes		
Health Indicators	Prevalence of chronic respiratory disease by sex and age in 5 year groups					
	Standardized mortality rate by sex and age in 5 year groups	HLTH_CD_ACDR	Causes of death by region - Crude death rate (per 100,000 inhabitants - 3 years average) - Total	1/328	5 year age classes	General and regional statistics/regions/Health satistics/
	COPD deaths by sex and age in 5 year	HLTH_CD_ACDR	Causes of death by region - Crude death rate (per 100.000	1/328	5 year age classes	General and regional statistics/regions/Health satistics/

Yearly data for HIA	Parameter	Name of the EUROSTAT table	Description	spatial resolution	note	path
	groups		inhabitants)			
	Cardiovascular deaths by sex and age in 5 year groups	HLTH_CD_ACDR	Causes of death by region - Crude death rate (per 100.000 inhabitants)	1/328	5 year age classes	General and regional statistics/regions/Health satistics/
	Lung cancer incidence rates by sex and age in 5 year groups	HLTH_MB_CANC =	Cancer - Absolute number of cases and standardised incidence rates - EUCAN/IARC data	15 countries	10 Year age classes / only 1997 and 1998	health/public health/ Health status: indicators from other surveys and sources/Morbidity
	Lung cancer mortality rate by sex and age in 5 year groups	HLTH_CD_ACDR	Causes of death by region - Crude death rate (per 100,000 inhabitants - 3 years average) - Total Malignant neoplasm of larynx and trachea/bronchus/lung (C32-C34)	1/328	5 year age classes	General and regional statistics/regions/Health satistics/
	Hospitalization rates	HLTH_CO_DISCH =	Hospital discharges by diagnosis and average length of stay	36 countries	many missing	health/public health/Health care: data and indicators from administrative sources and other surveys/In-patients and day case/
		HLTH_CO_INPE =	In-patient hospitalisation during the past 12 months by sex, age and educational level (%)	20 Countries	no discharge diagnoses	health/public health/Health care: indicators from the national Health Interview Surveys (HIS round 2004)
	Children respiratory health					
Geographical data	Area size	D3AREA	Area of the regions	1/1587		General and regional statistics/regions/demographic statistics/
	Area size	SCD_I	Indicators for sub-city districts at 2 levels	5940 geopolitical entities	many missing values	General and regional statistics /urban audit
	Area size	XD3AREA =	Area of the regions - Non-EU25 Countries	1/302		General and regional statistics/regions/demographic statistics/
	Long/latitude					

4.3.3 Conclusions on Health Status Monitoring

We conclude that an EU comprehensive health status monitoring suitable for short-term air pollution health effects assessment is not yet possible, but that data collection can be improved and reinforced on EU level.

Our search in the database showed that for spatial health status monitoring the EUROSTAT database provides most of the data needed in a fairly highly spatially resolved way. As for the temporal health status monitoring the needs seem to be fulfilled. On the other hand hospitalization data is incomplete on the EU level, and data on respiratory health is lacking.

4.4 Air pollution health effect assessment

No project on routine air pollution health effect assessment could be identified on national or EU levels, which are not research-like projects with a limited time horizon. However, there are a number of systematic review processes which are summarizing the evidence available recently. In the following we present some of the most recent projects conducted within the EU to

summarize air pollution health effects. These projects update exposure-response functions for policy purposes as well as for health impact assessment which is discussed in chapter 3.5.

4.4.1 Systematic review projects

Studies of air pollution health effects have shown coherent health effects ranging from low birth weight children to premature deaths. The expected health effects depend on the type of pollution, the persistence of elevated levels, and the frequency of susceptible individuals within the population.

AIRNET - Network on Air Pollution and Health

AIRNET is a network project initiated to develop an overarching European-wide framework for air pollution and health research. AIRNET collects, interprets and disseminates data from individual (EU-funded) projects, in order to strengthen the science policy interface and to draw policy-relevant recommendations. AIRNET is funded by the European Commission Program Quality of Life and Management of Living Resources (QoL), Key Action 4 - Environment and Health (Contract number: QLRT-2001-00441). AIRNET started on the 1st of January 2002 and was completed by 1st of January 2005. AIRNET has published reports on epidemiology, toxicology, health impact assessment.

http://airnet.iras.uu.nl/products/#airnet

APHEIS

Public Health Surveillance (PHS) is an ongoing and systematic collection, analysis, interpretation and dissemination of epidemiological information in the process of describing and monitoring a health event related to a risk factor. This information is used by decision-makers for planning, implementing, and evaluating public health interventions and programs. Surveillance data are used both to establish the need for public health action and to assess the effectiveness of programs. In the environmental field, PHS has some constraints due to the fact that most of the time, there are no specific outcomes and no specific exposure indicators. Applied to air pollution, this means that we have to monitor the exposure-response relationships. APHEIS aims to create an epidemiological surveillance system of the effects of air pollution on health. For the description of the surveillance system, APHEIS proposes an adaptation of the “Guidelines for Evaluating Surveillance Systems” of the Centres for Disease Control, some guidelines not being applicable to the surveillance of the effects of air pollution on health.

http://airnet.iras.uu.nl/products/reports_and_annexes/APHEIS/APHEIS_report_ii_v10.pdf

COMEAP – Department of Health - UK

COMEAP is an Advisory Committee of independent experts that provides advice to UK Government Departments and Agencies on all matters concerning the potential toxicity and effects upon health of air pollutants. Most members are appointed as independent scientific and medical experts on the basis of their special skills and knowledge. The one exception to this is the public interest member of the Committee who is appointed for knowledge of consumer, and other, matters. At all times individuals are required to declare conflicts of interest and during discussions they may be disqualified at the Chairman's discretion from contributing to the conclusions and recommendations of the Committee.

The independent members are supported in their work by a secretariat provided by the Department of Health. The secretariat has scientific expertise that enables them to provide

members with comprehensive background information and briefing papers that inform the decision-making processes of the Committee.

New systematic review on cardiovascular disease and air pollution was published in September 2005. http://www.advisorybodies.doh.gov.uk/comeap/PDFS/cardiovasculardisease.pdf

http://www.advisorybodies.doh.gov.uk/comeap/index.htm

European Union Clean Air for Europe (CAFE)

The Commission of the European Union has initiated the Clean Air for Europe (CAFE) program to strengthen their air pollution policy, based on the best available science and created in a broad, open, and transparent dialogue with a scientific community, as well as the public and the stakeholders. The objectives of CAFE are:

To review existing air quality standards and national emission ceilings as set out in recent legislation, and to contribute to the review of international protocols on the basis of the best and most recent scientific and technical information, taking into account experience of implementation of existing legislation and protocols;

To develop new, flexible and comprehensive mechanisms for gathering information leading, in the longer term, to the further development of objectives and indicators for outdoor air quality;

To identify where there may be a need for additional measures to reduce emissions from specific sources;

To propose and update a strategy at regular intervals which defines appropriate air quality objectives for the future and cost-effective measures for meeting those objectives.

europa.eu.int/comm/environment/air/cafe.htm

Systematic review of health aspects of air quality in Europe – WHO

The purpose of the project is to provide the EC DG Environment, and its Clean Air for Europe (CAFE) program in particular, with a systematic, scientifically independent review of the health aspects of air quality in Europe. The project updates the scientific evidence on health aspects of air pollution, aims to harmonize the methodology of health risk assessment of air pollution; and contribute to the estimation of the impacts of air pollution on health in Europe. Several reports were produced by the Systematic Review project. Among them were the report on "Health Aspects of Air pollution with Particulate Matter, Ozone and Nitrogen Dioxide", the report on "Meta-Analysis of time-series studies and panel studies of Particulate Matter (PM) and Ozone (O3)". As part of the systematic review, WHO has established a task group to perform a meta-analysis to derive concentration-response functions for PM and ozone for certain health endpoints from published time-series studies. These functions are suitable for calculation of health impacts of the mentioned air pollutants in Europe. Recently a report on the working group meeting, in Bonn, Germany, 18-20 October 2005 to globally update **WHO air quality guidelines was published.** Details can be found under

http://www.euro.who.int/air

4.4.2 Ongoing health effect assessment

In Europe and other countries health effect assessment is being mostly performed and reported based on irregular advances in scientific research projects. Currently, there is only one project, to our knowledge, related to continuous health effect assessment of air pollution: the US

iHAPSS (Internet-based Health and Air Pollution Surveillance System) project. Within the terminology employed in this report we regard this effort as continuous health effect assessment, but not a monitoring project since it is not assessing changes in health outcomes as indicators for air pollution related events.

The purpose of the research program is to create an internet-based system for “monitoring” the effects of air pollution on mortality and morbidity in US cities. The association between shorter-term fluctuations in concentrations of particles and other air pollutants with daily mortality and morbidity are assessed systematically. The data necessary for estimating these effects, including mortality and morbidity statistics, air pollution, weather, and demographic data, are routinely collected by several government agencies.

A web-based system that regularly accesses analyzes and disseminates policy-relevant data about the association of air pollution and mortality and morbidity in US cities is created. In Phase I of the project, the requisite public information and results of statistical analyses are posted to an iHAPSS website so that all constituents can stay informed about the most recent knowledge and its component parts. In Phase II to be considered under a separate proposal, a web-based methodology for easily conducting new, innovative analyses will be created.

http://www.ihapss.jhsph.edu/

4.4.3 Conclusions health effect assessment

There are various efforts under way to summarize the existing evidence on air pollution health effects. None of them are routine, which has the disadvantage that information is not gathered for policy purposes on a routine basis.

4.5 Health impact assessment

HIA is a practical approach used to judge the potential health effects of a policy, program or project on a population, particularly on vulnerable or disadvantaged groups. Recommendations are produced for decision makers and stakeholders, with the aim of maximising the proposals positive health effects and minimising the negative health effects. It has become a very powerful tool for the development of policies on PM. This is attributable to the fact that no thresholds for the PM health effects could be identified so far. Therefore, environmental protection laws have to weigh the costs associated with the health effects of PM against the costs associated with abatement of PM pollution. In order to arrive at cost- benefit analyses the health impact of PM exposure under current as well as future scenarios needs to be documented.

HIA is conducted in several EU wide projects as well as on national level to guide policies, to perform cost-benefit analyses and to communicate to which extend PM is affecting public health.

Below recent and ongoing research or review projects on health impact assessment are summarized. In order to obtain more information on the national level HIA, we conducted a survey among scientists of the Member States about activities in their country. However, reply was sparse. Of 28 sent out questionnaires, seven were returned (from Malta, Italy, Denmark Luxemburg, Ireland, Greece and France). Only the French and Italian scientists stated that health effects assessment as well as HIA is done routinely.

APHEIS (report 2 and 3)

The objective of health impact assessment (HIA) in APHEIS is to estimate the number of health events attributed to air pollution in the participating cities over a certain period of time. Guidelines for HIA were formulated (see Annex 6.9). In principle, estimates for a calendar year were estimated. In each centre, the target population is the population covered by the air quality monitoring network in the study area. The adequacy of the exposure estimates for the target population was assessed based on the available data from monitoring and pollution models, as well as expert judgment. Source: http://www.apheis.net

ExternE

The scope of the ExternE Project is to value the external costs, i.e. the major impacts of economic activities, both referred to production and consumption. Up to now, valuations of external costs have mainly been applied to energy-related activities such as fuel cycles, and activities related to transport of persons and freight, but the focus is being broadened and the methodology extended to activities such as different industrial processes. http://www.externe.info/

Further projects

Austria, France, Switzerland (1999): Health Costs due to Road Traffic-related Air Pollution. An impact assessment project of Austria, France and Switzerland	http://www.euro.who.int/transport/HIA/20021107_3
Health and Economic Impacts of air pollution	http://www.airimpacts.org/
Health Impact Assessment Gateway	http://www.publichealth.nice.org.uk/page.aspx?o=HIAGateway
WHO HIA	http://www.who.int/hia/examples/air/en/index.html
London Health Commission. HIA	http://www.londonshealth.gov.uk/hia.htm
Italy (2002): Health impact assessment of air pollution in the eight main Italian cities	http://www.who.dk/document/E75492.pdf
Committee on the Medical Effects of Air Pollutants (COMEAP)	http://www.advisorybodies.doh.gov.uk/comeap/
Report: The quantification of the effects of air pollution on health in the United Kingdom	http://www.advisorybodies.doh.gov.uk/COMEAP/statementsreports/AIRPOL7.HTM
WHO Europe AIQ programme	http://www.euro.who.int/air
Health impact assessment of air pollution in the WHO European region: request by e-mail	info@ecehbonn.euro.who.int
The CAFE Programme	http://europa.eu.int/comm/environment/air/cafe/index.htm http://europa.eu.int/comm/environment/air/cafe/general/keydocs.htm
Institute of Environment and Health (IEH)	http://www.silsoe.cranfield.ac.uk/ieh/hia/hia.html
ExternE: Report on: External Costs Research results on socio-environmental damages due to electricity and transport	http://www.externe.info/
INTARESE: EU project	http://www.imperial-consultants.co.uk/intarese.org/overview.htm

4.5.1 Conclusions health impact assessment

Research projects standardizing and applying health impact assessment methods are recently completed or currently being conducted. Time and area resolution is often different for population exposure values and population health status monitoring. Population health is monitored on national and regional level. Data needed for HIA, spatially highly resolved but temporarily aggregated, is available as yearly averages through EUROSTAT.

5 New Practical Concept

The analysis of the current situation in the EU with respect to health relevant air quality monitoring and health data processing (see sections 3 and 4) reveals three main areas where improvements are necessary:

a) Improvement of the assessment of routine air quality monitoring data in order to obtain air pollution data which are more reliable and representative to calculate the exposure of the population
b) Improvement of the health status data acquisition and processing in order to allow for timely and routine assessment of short-term health effects
c) Improvement of the generation of additional data needed for long-term health effect and health impact assessment for the EU Member States

The following section describes a practical approach to achieve health effect assessment based on routinely acquired data by the European Member States as well as by newly setup research initiatives across Europe taking the above mentioned problems into account.

While some Member States are collecting relevant data routinely, there is no European wide uniform approach available so far. Also, some local research initiatives may be used as models for an integrated assessment of air pollution health effects. A uniform approach is needed involving several Member States to adequately characterise the health effects of ambient air pollution in the future.

Some extension to the routine efforts and additional research efforts beyond routine measurements are needed because

- current routine efforts do not include health effect assessment for short-term effects and health impact assessment,
- routine air pollution monitoring is unable to provide data on new not regulated components or characteristics of (urban) air pollution,
- routine air pollution monitoring does not provide the data to identify sources of pollution responsible for the air pollution health effects,
- routine health status monitoring does not provide data to be applicable for addressing long-term health effects,
- routine health status monitoring does not provide data to identify susceptible subgroups within the population,
- current routine efforts do not include health effect assessment for short-term effects and health impact assessment,
- routine health effect assessment does only provide limited insight into the mechanisms responsible for the statistical associations observed in population based studies.

The proposed practical concept is geared to provide the information needed by the EU to quantify the impact of changes in air quality. In order to demonstrate accountability, it does not seem to be sufficient to update the current health impact assessment based on the revised estimates of air pollution exposures of the European population. It also is necessary to update exposure assessment, exposure-response functions and to apply these updated functions in health impact assessment, because the currently implemented abatement strategies will alter the air pollution mix and thereby its impact on human health. In order to adequately guide future decisions on control strategies it seems to be crucial to demonstrate the accountability of the

measures taken today. Figure 17 provides a schematic how routine health effect assessment and superregions could complement each other and lead to improved health impact assessments in the future.

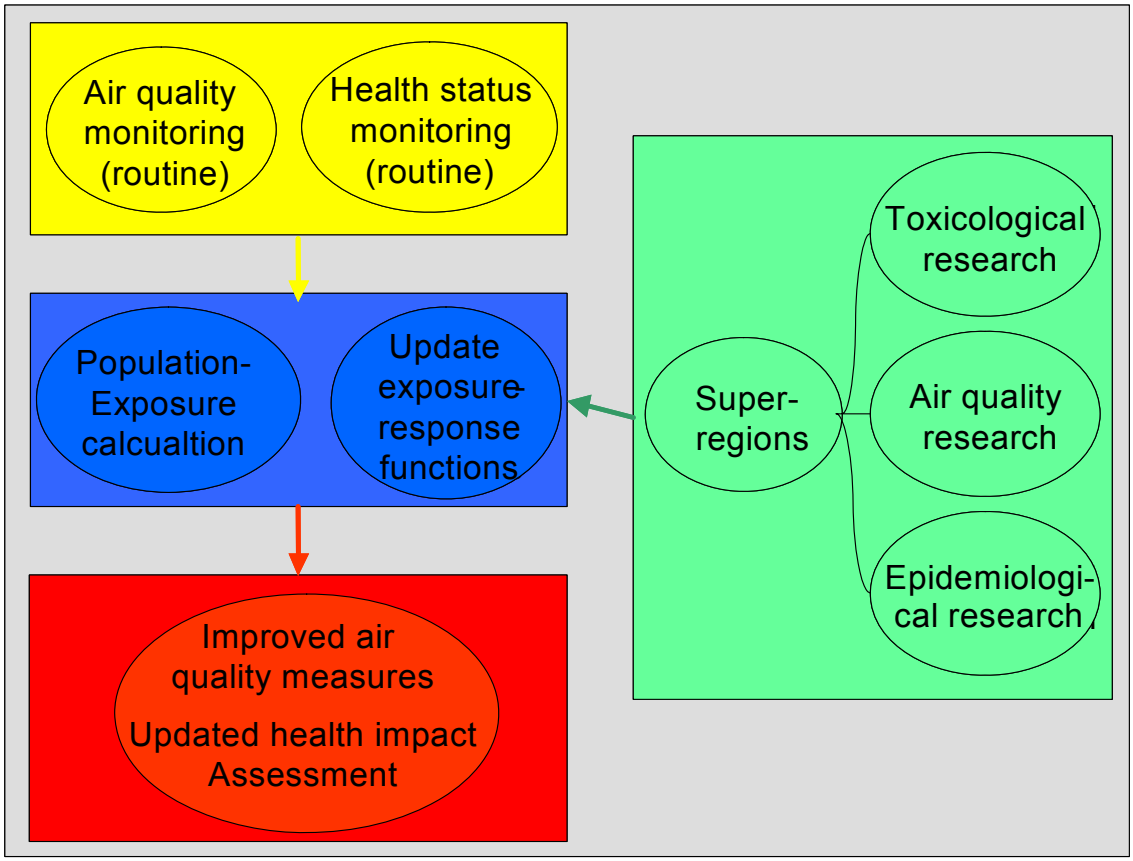


Figure 17 Schematic of proposed practical concept

The value of the efforts described below would increase significantly if all data and information would be in a format which can be linked to a GIS-based database. Hence, wherever feasible it is recommended to include this option if practicable. The requirements for routine health impact assessments are specified in more detail below using following structure: air quality monitoring and exposure assessment, health assessment, and research needs and superregion concept.

5.1 Air quality monitoring and exposure assessment

The accuracy of air quality data as given in the 2nd daughter directive for a single measurement of ± 15% for gaseous pollutants and of ± 25% for PM is currently seen as sufficient taking into account the spatial and temporal uncertainties for the exposure assessment. Nevertheless it has to be ensured that the systematic error is not larger than the values given in step 4 of chapter 5.1.3.1. However this view may change once the exposure assessment methods have been improved.

5.1.1 General considerations, requirements and limitations

To become more health relevant, air quality monitoring data must be acquired in a way that data can be used for calculation of population exposure. This means that air quality data must be representative for the main situations in which people are exposed to air pollutants. Ideally, it would be possible to construct the exposure distribution curve (c. f Figure 18) from the air quality monitoring data.

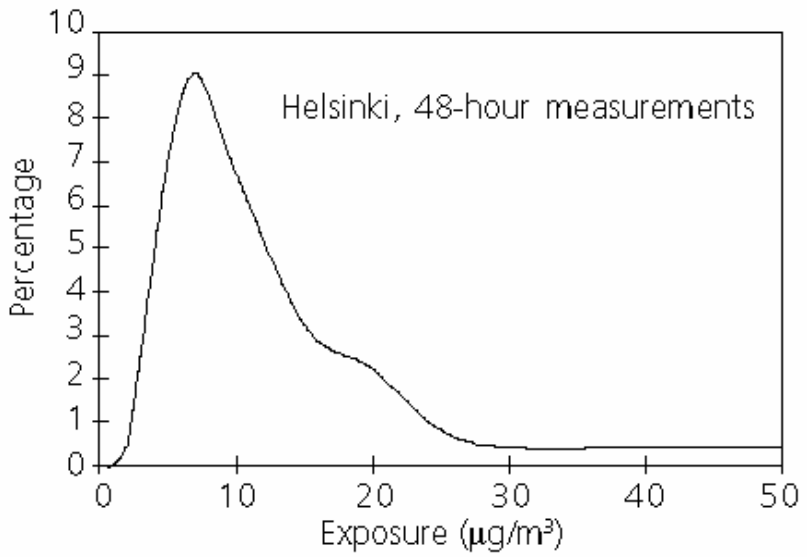


Figure 18 Distribution of 48-h $PM_{2.5}$ exposure among the working-age population of Helsinki measured by the EXPOLIS study (graph taken from WHO 1999).

To achieve this, the determination of the integrated personal exposure ($\int c(t)dt$) for each individual would be necessary to accurately evaluate the population exposure. Obviously, this is not possible. Even if a representative group of individuals was chosen to evaluate this distribution the effort to be spent would be enormous due to the high variability of individual behaviour and of air pollutant concentrations in space and time. Additional constraints are imposed by the lack of appropriate personal measurement devices for all compounds of concern. Hence, organisational and cost reasons will necessarily limit such an approach to very confined studies (like e.g. the EXPOLIS study).

The way out of this dilemma with respect to routine exposure measurement is to approximate population exposure from outdoor concentration measurements at sites located in the various situations in which people are exposed to air pollutants (traffic, urban, suburban, rural). The limitation to outdoor measurements of course means that indoor exposure, being the most frequent exposure situation for many people, is considered incorrectly to some degree. Fortunately, for a number of other relevant pollutants (e.g. PM, soot) indoor and outdoor concentrations appear to be reasonably correlated (for more information, see Annex 6.3).

Still, some information on population behaviour can be important to assess population exposure from the measurement results. Table 13 gives an assignment of inhabitant numbers (or relative shares of population) to different measurement environments and the average time spend therein. In this example, the average (arithmetic mean) concentration of the four measurement sites is 42.5 µg/m³. Population exposure is calculated to be slightly less than this value, 41.8 µg/m³ by taking into account the distribution of the population subgroups and their time spend in the different environments. Hence, for the concentration values selected in the

example shown the population exposure is reflected quite well by the arithmetic mean of the measurement results.

Table 13 Example for exposure calculation using 3 microenvironments and 3 population subgroups (WHO 1999)

Population group (size)	Fraction of time assigned to each station (average PM_{10} concentration in (µg/m³)				Calculated exposure (µg/m³)
	Centre (50)	Road traffic (70)	Suburban (30)	Suburban (20)	
Not employed, including children (100 000)	0	0	0.5	0.5	25
Employed and commuting (500 000)	0.3	0.1	0.3	0.3	37
Centre residents (400 000)	0.9	0.1	0	0	52
Total population (1 000 000)	0.51	0.09	0.20	0.20	42

However, it may be easily computed that – while keeping the same mean value – a change of the concentrations at the sites – within reasonable boundaries - will result in more different population exposure. This is illustrated in Table 14.

Table 14 Comparison of average concentrations and population exposure for various combinations of site concentrations (sites and population Distribution as in WHO 1999; all values in µg/m³)

Suburban 1	Suburban 2	Centre	Traffic	Average	Pop exposure
20	30	60	60	42.5	46.0
20	*30*	*50*	*70*	42.5	*41.8*
25	25	45	75	42.5	39.7
20	25	45	80	42.5	39.1
20	25	40	85	42.5	37.1

Thus, the uncertainty in population exposure introduced by ignoring the different shares of exposure situations may easily reach ± 10%.

In conclusion, a health related network for monitoring ambient air pollution ideally must

1. give definitions of population subgroups and - as far as feasible - an assessment of their particular vulnerability towards air pollution compounds;
2. define the relevant exposure situations the population subgroups experience;
3. include an assessment of the time fractions which are spent by the different subgroups in these exposure situations;
4. delineate the territory (country, region, area) these definitions and assessments are valid for;
5. obtain concentration data measured in environments reflecting typical exposure situations, with at least one site per particular environment;

6. provide for a calculation scheme to derive an estimate on the mean population exposure from the measured concentrations which takes into account the factors mentioned in 1. – 4 (e.g. site specific weighing factors).

This ideal concept should be approached as far as possible. However, due to economical reasons and practicability compromises must be made. In particular the requirements 1, 2 and 3 are difficult to realise. In the simplest approach, population may be taken as a whole, the main exposure situation assumed to be “staying where living” and the time spend in that exposure situation assumed to be the whole day.

In such “static” model the population numbers are equal to the number of the residential population and the exposure concentrations related directly to the concentration measured in the area where people are living. Hence, different concentration levels correspond to various types of areas which differ by their air pollution characteristics.

5.1.2 Population exposure distributions

The exposure distribution of the static model can be converted into a population/area-type histogram as shown in Figure 19.

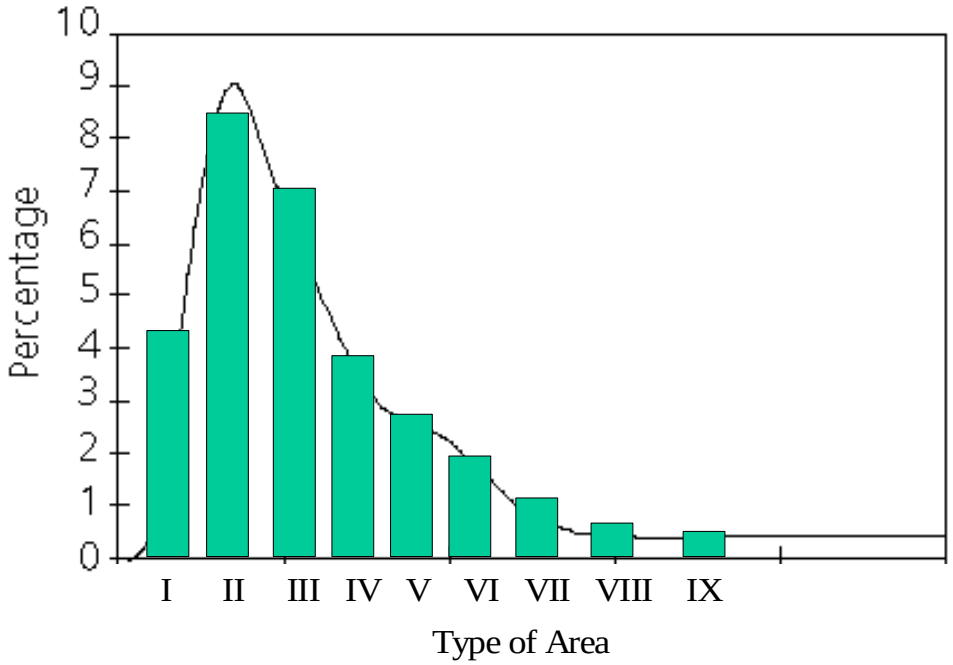


Figure 19 Converted exposure distribution for assumption of static exposure situations

The number of these different area types within a particular region will depend on both the variations of air pollution concentrations occurring and the significance of observed differences for the associated health effects. Generally, a broader range of observed concentrations will also lead to more area types representing the distribution. However, in case the exposure – response functions have a low slope, higher differences in the concentrations are needed to generate significant changes in health effects. In such cases less area types would be sufficient.

To obtain reliable exposure values representative monitoring in the different area types is needed. As outlined before, the number of these area types is not known a priori and it should not be fixed regardless of pollutant and region of interest. As shown in chapter 4, the approach used up to now by predefinition of area types like urban/suburban/regional background with e.g. area use subsets (residential, commercial, industrial) appears to be insufficient, because assignment of these classifications to areas can often be ambiguous and subjective, and the borders of representativeness are difficult, if not impossible to delineate.

Therefore, there's the need for a methodology to

1. identify the various types of areas being different with respect to their air quality situation in a given region,
2. group or part these areas in an objective way,
3. assign key characteristics to each type which can be used to compare the air quality between similar area types in different regions/countries,
4. deliver indicators which can be used for the decision where monitoring stations should be installed and which components should be measured.

5.1.3 Outline of a new methodology for determining representative measurement locations

In the following, an outline of a methodology is presented which shall be able to fulfil the requirements mentioned before. It is partly based on experiences already available from research programs executed by network operating authorities, e.g. in North Rhine Westphalia, Germany and also takes into account publications in the scientific and other literature (Chow et al., 2002; Kousa et al., 2002; Venegas and Mazzeo, 2004; Cyrys et al., 2005; Umweltbundesamt GmbH, 2005).

The methodology proposed here comprises 4 key steps:

1. Identification of hot-spot areas and air pollution modelling for a pre-selected region,
2. Identification and grouping of areas with similar characteristics regarding the pollution situation by means of (multivariate) statistical analysis,
3. for each grouped area type, determination of existing representative measurement locations or necessary new measurement stations,
4. assignment of relevant population numbers to each area type and pollutant for use as weighing factors in the calculation of the population exposure for the region of interest.

Regarding step 1 some general considerations should be noted.

Looking at the population – area type histogram which is typical for an agglomeration it is obvious that there will be a few hot spot areas with high exposure. The identification process should start with these, since the fraction of population belonging to them must be separated from the larger fraction being exposed to background levels. Hot spot areas comprise street canyons where traffic emissions are accumulated and industrial sites with near ground emission sources. Usually, traffic hot spot areas are in the range of a few 100 m of road length, influencing the concentrations alongside up to a distance of some 50 m. The size of industrial hot spot areas ranges from a few hundred m² up to some km².

Even though the fraction of population exposed to high levels might be low such situations should be considered, since e.g. in case of pollutants with health effect threshold levels hot-spot exposure can be the major reason for health effects. Additionally, although measures to improve air quality will probably also affect hot spot locations, the reduction of exposure at such sites may be less than proportional.

Therefore the air pollution modelling step must be performed with high spatial resolution. In the case of traffic hot spots, special models allowing for accurate implementation of the street canyon geometry must be used. For industrial sites common dispersion models with high grid resolution (< 1 km) should be applied.

The identification of the areas where such high resolution modelling is needed can be done using GIS based screening models in case of traffic hot spots [LUA, 2003], and data from emission registers in case of industrial areas.

Also with respect to the further key steps 2 – 4 there are differences between traffic and industrial hot spot areas. While traffic areas have a common emission source and might exhibit – due to the limitation to street canyons – quite similar concentration levels, the emitted compounds can differ considerably between industrial sites (if e.g. comparing steel industry with oil refineries). Hence, it may be that the statistical analysis would reveal a quite high number of different industrial area types. In order to avoid unnecessary efforts of air quality monitoring, a further selection step will be needed to decide on the location for monitoring stations. A criterion could be the number of people affected by the emissions in conjunction with the concentration level compared to background concentrations. This additional methodology should be developed within a pilot study, using different situations (industrial site located in agglomerations, rural areas, good and bad dispersion conditions) to achieve as far as possible a universal applicability.

Once the hot-spot areas are identified and delineated the population being exposed there can be calculated and subtracted from the entire population in the region of interest to give the number of people living in background exposure situation.

To model the concentrations of these background areas a lower spatial resolution is sufficient. Principally, a large variety of methods using measured and model data or combinations of both are available to produce concentration maps. Very recently, a comprehensive review of available methods for data interpolation and data assimilation to produce concentration maps from monitoring and/or modelled data has been published by the EEA [Denby et al, 2005]. The background demand for this study was the need of air quality maps to be used for air quality assessment and for public information rather than for providing exposure data.

The EEA study comes to the conclusion that the analysis of measured concentration data in combination with supplementary information (e.g. on meteorological, land-use and orographic characteristics) by kriging/co-kriging methods would be recommendable. However, it is also clearly stated, that the use of data assimilation which involve complex modelling with high computational effort "…is perhaps the most promising method for creating the best concentration fields of pollutants…". Such methodology is however …"not easily accessible and is still a developing research area."

In view of the health relevance, the costs and consequences of possible measures to improve air quality the availability of highly reliable concentration data to assess population exposure is considered to be of paramount importance. Therefore, for the key step 1 in the methodology proposed here the use of data assimilation comprising complex air chemistry transport models (CTMs) is recommended, being well aware of the difficulties to apply such models everywhere and to the need of additional research and development efforts to be made in this field.

CTM modelling has already been carried out down to a resolution of 1x1 km² (c.f. Figure 20); however, significant differences could be occasionally observed to model runs with lower spatial resolution. Additionally, the computational effort largely increases with increasing resolution. Hence, a resolution of 5x5 km² appears to be a recommendable starting base. Moreover, modelling should be done for the most relevant pollutants only (NO_2, PM, O_3) to keep the effort reasonable.

The EU project CityDelta, led by JRC Ispra, has conducted a comparison between various CTMs by applying them to a number of European cities. Results of this project should be taken into account when selecting the models to be used for the purpose of area characterisation.

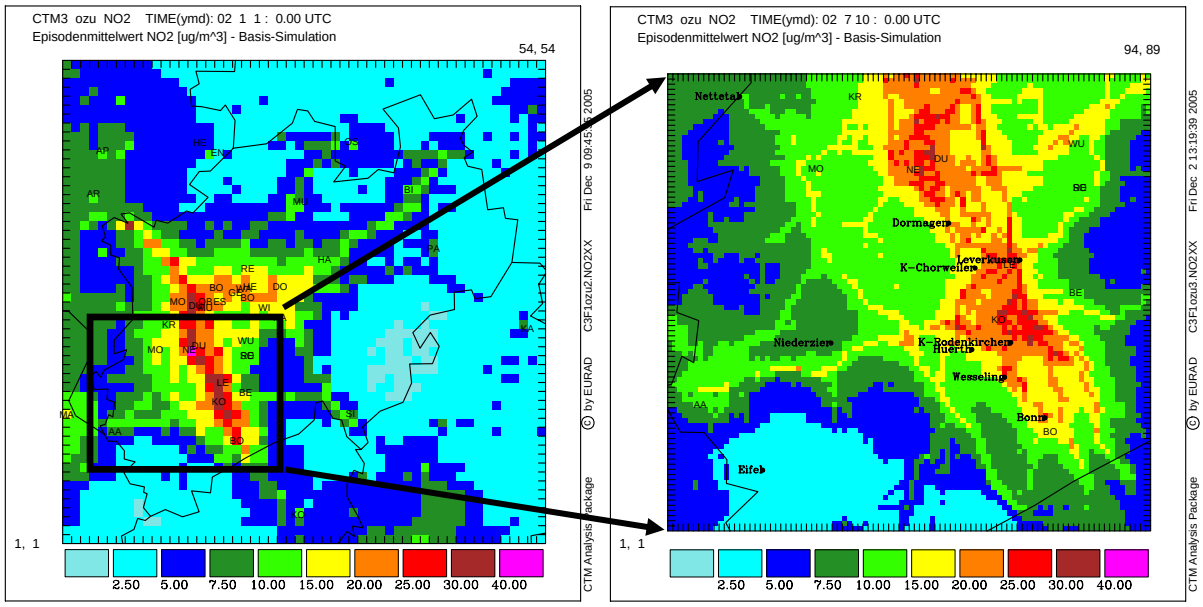


Figure 20 Modelled NO2 concentration for the region of Cologne and Düsseldorf, Germany; EURAD-Model; left side 5 km grid resolution, right side 1 km grid resolution[14]

5.1.3.1 *Construction of the population exposure distribution for background exposure*

In the following the entire proposed procedure to identify and characterise the area types for background situation is described in more detail. It is presumed that hot spot areas have been identified before and the population exposed in these areas has been subtracted from the grid areas used for the valuation of background area types.

In Figure 21 the general scheme proposed for the determination of the population exposure based on representative monitoring is shown. It comprises 10 steps which are explained briefly.

Step 1: Definition of the region the analysis should be made for

The selection should take place taking into account at least following criteria:

- climatic zone
- orography
- meteorology

[14] Kindly provided by M. Memmesheimer, RIU, Cologne, calculated in a project 'OZURMI' sponsored by the LUA NRW, Germany.

- land use
- (administrative boundaries)

Step 2: Determining grid cell size

Dependent on the area size and on observed variations in characteristics which influence the air quality the size of the model grid has to be determined. If needed, nested grids may be applied.

Grids should not be larger than 5*5 km².

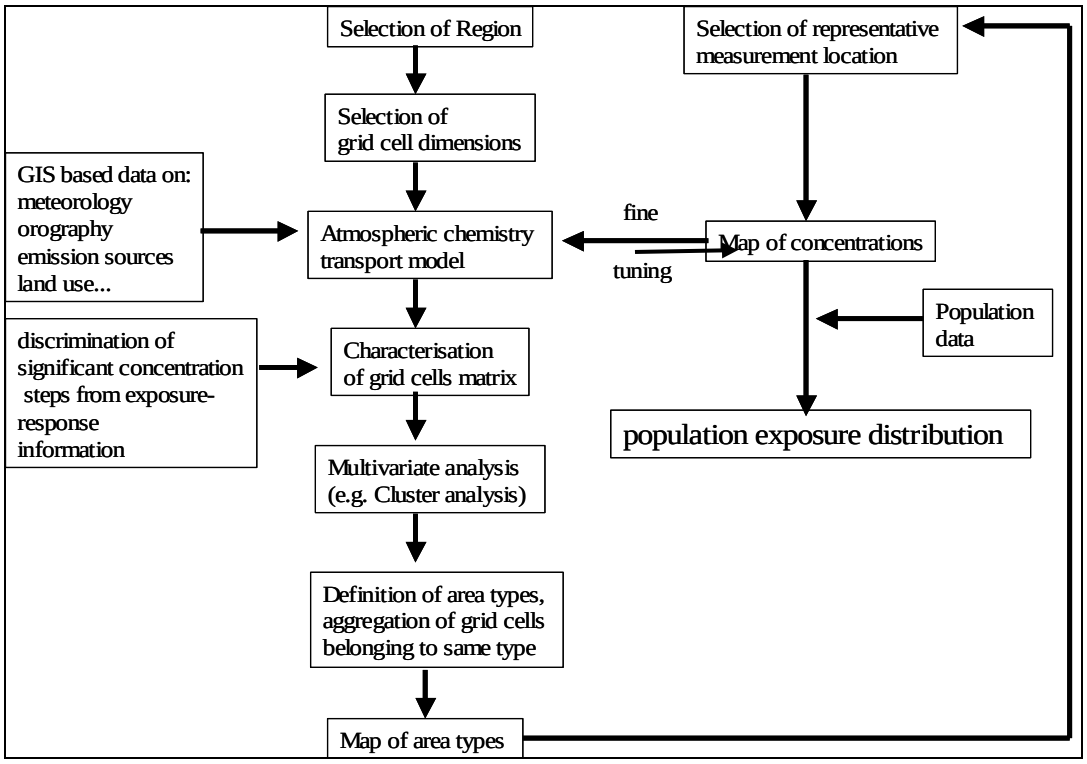


Figure 21 Scheme for evaluation of a population exposure distribution from representative air quality monitoring

Step 3: Model calculation

Using a complex air chemistry transport model it is possible to evaluate the influence of a multitude of factors (orography, meteorology, emission source structure and variations) on the air quality and to derive concentrations for any targeted pollutant per each grid cell.

Step 4: Filling the matrix

The concentration values obtained from the model calculations are used to fill the cell/pollutant matrix. Both, average and maximum concentrations can be used, as well as combinations and ratios of air pollutants. Concentration levels may be discriminated stepwise with increments. They should be defined by the Member States or EU and be revised over time. Such increment could be for instance:

- for PM-10: 3 µg/m³
- for PM-2.5: 2 µg/m³
- for NO_2: 3 µg/m³

- for O_3: 10 µg/m³

Step 5: Statistical Analysis

Statistical analysis is used to separate and group the grid cells into classes with similar characteristics. There is a multitude of applicable methods having their own advantages and disadvantages. Examples are:

- regression analysis
- Coefficient of divergency
- multivariate statistics (cluster analysis, factor analysis, principal component analysis)

Most probably, a combination of several of these methods will give the best results.

Step 6: Definition of area types

Grid cells which have been clustered by the statistical analysis are supposed to belong to one area type. Plausibility checks must be done to verify this. In case of inconsistencies, the matrix may have to be modified and step 5 to be repeated. Also singularities (e.g. grid cells with industrial hot spot) shall be identified and separated for further consideration. Vicinal grids of same type are aggregated.

Step 7: Map of area types

Maps of the targeted region indicating the spatial distribution of the area types are produced. Possible hot spot areas are identified and treated separately (see chapter 5.1.3.2).

Step 8: Identification of grids where measurement stations should be placed

An analysis of parameter variations between grid cells for each area type shall be performed to determine average characteristics. Those grids representing these average characteristics are identified. Measurement stations are already, or should be placed in one or more of these grids, preferentially in aggregated areas of the same area type. Population numbers and the variance of parameters should be taken into account.

Step 9: Preparation of concentration maps from monitoring data

Using the data from the selected monitoring stations concentration maps are produced by transfer of measurement data to grid cells without monitoring. Model calculations can be used for fine tuning (and vice versa). Concentration maps can be constructed for the different determined air pollutants. The maps may be extended to ‘source contribution’ maps using the results of the applied dispersion models, thus allowing for linking pollution sources to health effects. Still, this latter step needs throrough evaluation before application.

Step 10: Construction of population exposure distribution

Finally, population numbers are assigned to the grid cells and the population exposure distribution is constructed for the background exposure. These values still have to be corrected for hot spot related exposure as discussed below. Industry related hot spots (their

corresponding grids) are excluded whereas traffic related hot-spot exposure must be calculated separately and be deducted from the values calculated in this step.

This approach assumes that the ambient air quality at the place of living is the 'correct' exposure value. The extend to which this assumption is valid and varies within Europe is unknown. Hence, personal exposure studies should be conducted reflecting the variation in the population and life styles in Europe.

The methodology outlined before should in principle be applicable in all European countries and regions. The number and characteristics of area types evolving from the statistical analysis may differ from region to region. It should be noted that an important prerequisite is the availability of a suitable air chemistry transport model and of the input data needed for this model. Since several models exist which may be used it is recommended to test and compare these in the framework of a pilot study aiming at the characterisation of selected regions that mirror the European variability, e.g. superregions. Moreover, the best statistical tools for clustering grid cells into area types have to be searched for.

The result of this effort would be a population exposure distribution as shown in Figure 18/19 with respect to the different air pollutants and for different regions/areas. These data along with health status data reported in a format linkable to a GIS-database (e.g. related to INSPIRE) would enable health impact assessments for larger areas.

5.1.3.2 Conclusions and recommendations

The ultimate goal of a health-relevant air quality monitoring system is to provide a map of pollutant concentrations which can be converted into the population exposure distribution by use of information on the population distribution. To achieve this, a standardised and objective methodology to construct a map of pollution related area types is needed. The requirements for such a system and a possible approach to reach the targets, based on extensive air quality concentration modelling and multivariate statistics, have been outlined. Additionally, further steps to cover industrial and traffic hot spot situations have been proposed.

There are already a considerable number of air chemistry models and screening approaches available in Europe. A priori it cannot be assessed which may be the optimum solution, and maybe combinations of different models will have to be applied. Fortunately, the City-Delta project will provide comparisons of some of the available models under well-controlled conditions.

Hence, it is recommended to initiate pilot research studies with respect to the various key steps of the methodology needed:

- air chemistry transport models applicable down to a resolution of least 2*2 km
- evaluation of tools and statistical methods to discriminate and cluster area types based on modelled AP concentrations
- screening models for identification and modelling of traffic hot spots
- methods to identify and delineate industrial areas and valuate the population affected by the corresponding emissions

5.1.4 Air pollution components to be measured

Table 15 summarizes the recommendations for AP to be monitored in the routine networks and in the superregions. It can generally be said that no changes to the routine network are recommended.

Table 15 List of air quality parameters suggested to be measured on a routine as well as on a superregion location

Component	Suggested to have health relevance based on toxicology	Suggested to have health relevance based on epidemiology	Should be measured in routine network	Should be measured at superregion
O_3	Yes	Yes	Yes	Yes
CO	Yes	Yes	Yes	Yes
SO_2	Yes	Yes	Yes	Yes
NO_2	Yes	Yes	Yes	Yes
PM_{10}	Yes	Yes	Yes	Yes
$PM_{2.5}$	Yes	Yes	Yes	Yes
$PM_{(2.5-10)}$	Yes	Yes	Yes	No
PM_1	Yes	Yes	No	No
UFP	Yes	Yes	Yes[1]	Yes
Nitrate	No information	No information	No	Yes
Sulphate	No	Yes	No	Yes
Ammonium	No information	No information	No	Yes
Soot (Black smoke)	Yes	Yes	Yes[1]	Yes
PAH	Yes	Yes	Yes*	Yes
Benzene	Yes	Yes	Yes*	Yes
Organic carbon speciation	Yes	Yes	No	Yes
Sea salt (Na, Mg, Cl)	No information	No	No	for SoAp
Ca	No	No	No	for SoAp
K	No	No	No	for SoAp
Fe	Yes	Yes	No	Yes
Ni	Yes	No information	Yes*	Yes
Zn	Yes	No information	No	Yes
Cu	Yes	No information	No	Yes
As	Yes	Yes	Yes*	Yes
Sb	No information	No information	No	for SoAp
Cd	Yes	Yes	Yes*	Yes
Pb	Yes	Yes	Yes*	Yes
Mn	Yes	No	No	Yes
Cr	Yes	No	No	Yes
Biological particles (pollen, spores, etc.)	Yes	Yes	No	Yes
Fibers and man-made nanoparticles	Yes	Yes	No	Yes

* as required by the corresponding air quality directive
for SoAp: for source apportionment
[1] strongly recommended but after the methods have been standardized

5.2 Routine health assessment on Member States level

5.2.1 Routine health effect assessment

Routine health effect assessment is based on both, routine assessment of air pollution monitoring and routine health status monitoring followed by statistical analyses of the two based on established and similar statistical methods. It focuses on short-term health effects ranging from hours to months of exposures. Assessment of long-term health effects is not feasible

based on routine monitoring. Routine air pollution health effect assessment should be conducted without major delays between data collection and its analyses and should be available for all Member States for selected regions. All data needs to be stored in a uniform, and if possible in a GIS-based database to facilitate the analysis stage.

Health effect assessment should be done routinely in a way that it covers all climate zones, population exposure levels, population structure including health status, urbanization degrees, and other aspects that may be responsible for the observed heterogeneity of air pollution health effects within the EU. For this purpouse routine health assessment should be carried out in each member state at a selected number of regions. The results should be evaluated by experienced air pollution epidemiologist. If health effects are observed to be homogeneous, the number of areas chosen may be reduced.

Health data

It is recommended that routine health status monitoring is based on complete ascertainment of premature death, hospital admission data and data indicating health in children and infants. We propose to routinely monitor by surveillance systems in each member state:

- Daily counts of cause-specific mortality
- Daily counts of cause-specific hospital admissions for adults and children
- Daily counts of respiratory infections in children
- Daily counts of individual records on birth outcomes and malformations in newborns

As documented in chapter 4.3.1 some of this data is available on a routine basis in the Member States. Minimum requirements for data analyses are that for a given urban area the number of events is given by date. Ideally, data for each event would be available including

- Date of the event
- ICD codes of event
- Age and gender
- Location of event and code of hospital
- Place of residence of the individual

For uniform assessments, data collection procedures should be based on standard operating procedures specifying coding instructions and handling of missing information.

Confounder data

Routine ascertainment of meteorological data should be conducted. Here, data from one measurement station might be sufficient for an urban area or region unless there are large geographical differences resulting in local differences in weather. For birth outcomes, information on important risk factors associated with the mother or the course of the pregnancy should be collected on an individualized basis. Data collection procedures should be based on standard operating procedures specifying coding instructions.

Statistical Analyses

Statistical analyses should be conducted based on implemented statistical procedures requiring minimal additional specific programming. Based on standardised data formats, model selection should be based on standardised approaches. With the advancement in statistical models these functions can be regularly updated. All results should be stored in uniform, GIS-linked formats to

allow the assessment of similarities and differences within statistical models chosen over time. Effect estimates shall be stored and reported in a pre-specified way.

Summary estimates

Summary estimates of the data from all Member States can be calculated using meta-analytical methods. Meta-regression analyses can be conducted to investigate the potential of differences in health effects estimated between regions of the European Union, over time and in association with changes in air quality. This last step requires scientific expertise and is the only non-standardized procedure within in this section.

5.2.2 Health impact assessment

Health and population data

For HIA purposes, the underlying incidence of the health event of interest in the target population should be provided by routine spatial health status monitoring (GIS-based) in the EU. If an effect modifier has been identified (e.g. age group) – the incidence for each level of the effect modifier will be necessary.

The number of cases of the outcome X (annual) in the target population should be collected. These data are required on the same regional level as the different air pollution categories.

For each outcome and for each air pollution category the number of cases per year, the population at risk, the source of data, the reference for methodology of registration of the health data of concern as well as possible sources of uncertainty in the data should be specified.

5.2.3 Conclusions on routine health impact assessment

We recommend using an improved routine air quality monitoring together with a health status monitoring that is routinely collecting relevant data to evaluate air pollution health effects. These updated exposure-response functions will allow monitoring the accountability of current air quality measures taken. To further improve air quality directives and to guide future policies additional research efforts are needed and we propose to implement a “Superregion” concept for air pollution health effect research. This seems necessary to assess the long-term effects of air quality.

5.3 Research needs and superregion concept

Several research and development needs were presented in the previous section. The superregion concept was already introduced at the beginning of this chapter (see Figure 17). This section is to summarise the R&D needs for the set up of a health relevant air quality and health effect monitoring network as well as research tasks and requirements for the superregions.

5.3.1 R&D to set up European health relevant air quality monitoring

Air quality data, exposure assessments and exposure-response functions for the various health endpoints for mortality and morbidity are necessary. Major R&D activities in these areas are:

- Analysis and development of techniques to define areas of representativeness for air quality measurements,
- Identification of lacks of information on the spatial resolution of e.g. emission inventories needed for modeling,
- Identification of the importance of hot-spot situations on health effects and on health impact assessment,
- Set up of reporting requirements to allow for the evaluation of population exposure distributions for different regions and Member States in the EU,
- Identification of PM-characteristics which are health relevant. It has to be noted and stressed again, that PM mass and number concentrations are only air quality indicators but not by themselves health relevant.
- For exposure assessment currently only the assumption “staying where living” can be used. Effects such as the influence of different time activity patterns for different subgroups and regions in Europe on health outcomes have to be studied and evaluated.

5.3.2 R&D to be conducted at superregions

The superregions should provide possibilities to assess air pollution health effects in an integrated way addressing at least the research questions listed below.

R&D tasks include

- Quantification of long-term health effects in a changing environment,
- Identification of possible influences of life-style and climate on the relation of personal to ambient air exposure,
- Identification of Europeanwide and regional differences in air pollution health effects,
- Characterisation of the health relevance of new, unregulated components or characteristics of (urban) air pollution,
- Identification of the sources of pollution responsible for the air pollution health effects,
- Identification of the relevant time-scales of particle health effect induction which may range from hours to years depending on composition of the particles and on the considered health effects,
- Identification of the susceptible subgroups within the population with repect to different air pollution components and diseases,
- Identification of the mechanisms responsible for the statistical associations observed in population based studies,
- Development of a standadized source apportionment methodology for the exposure assessments in the superregions.

This information is not available based on routine air quality monitoring or health status monitoring. Local research initiatives may be used as models for an integrated assessment of air pollution health effects, but again a uniform approach is needed involving several Member States to adequately characterise the health effects of ambient air pollution in the future.

A major issue is the need to assess long-term health effects based on European data, since the current cost benefit analysis is mainly based on US data.

The proposed superregion concept shall provide the information needed by the European Union to quantify the impact of (changing) air quality

5.3.2.1 *Data requirements and collection procedure for superregions*

Air pollution and source apportionment

Additionally to the routine monitoring, some specific sites collecting and analysing routinely all components listed in Table 15 for the superregions should be determined. The source apportionment methodology should be applied using concentration maps. Comparison of source apportionment results obtained by dispersion modelling and by measurements / statistical analysis should be conducted to validate any results.

Exposure Assessment

Studies on time activity patterns and their applicability for health effect assessments should be conducted to validate the proposed approach. These studies should include the monitoring of personal exposure to validate models on time activity pattern, air pollutant concentrations and personal exposure. It is proposed to also calculate the source related exposure using the results of the source apportionment studies.

Health data

Data collection should address the long-term health effects of ambient pollution in adults, children and infants assessing cardiopulmonary and neurodegenerative diseases in adults as well as respiratory diseases in children. Disease development from children into adulthood shall also be assessed for diseases such as for example respiratory and cardiovascular diseases to estimate the life-time burden of exposure to ambient air pollution. For this aim cohort studies should be set up in the superregions. These studies will have to be conducted for several years to get reliable results on the long-term health effects.

More information is needed to which extent short-term changes in risk factor profile or exacerbation of existing diseases contribute to the long-term health effects observed.

The susceptibility of subgroups of the population may be studied in small targeted studies at the super-site locations.

Data on confounders should be collected locally based on the research question addressed and the study design selected.

All data collection procedures should be based on standard operating procedures and accompanied by quality assurance measures. They also should be linked to the GIS-database.

Toxicological studies

Toxicological studies may utilize particles sampled and characterised at the super-sites. In addition, they should guide epidemiological research in selecting their approaches as well as be linked to approaches taken in the epidemiological studies.

Both routine health effect assessment as well as targeted research activities outlined above will result in

- Better estimates for population exposures to regulated pollutants in Europe after introduction of tighter controls
- Estimates of population exposures to unregulated air pollution parameters
- Updated exposure-response functions for regulated and unregulated air pollutants in a changing environment
- Updated exposure-response functions for susceptible subgroups
- New exposure-response functions for previously unstudied diseases if there are health effects identified (for example: neurodegenerative diseases)

Thereby, novel information can be used for health impact assessment. In particular this data will provide information on accountability of the abatement measures and may identify larger or smaller health benefits as originally estimated based on health impact assessment.

6 Annexes

6.1 Annex A: References

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6.2 Annex B: Why is real time health effect monitoring of air pollution impossible?

Since air pollution is one of many influences on health, the attribution of an observed change in population health to an associated change in air pollution is not straightforward. In particular, the variation in the health outcomes is larger than the expected variations in the health outcome due to changes in air pollution concentrations. Also, health effects of air pollution are small in relation to other risk factors under current conditions. Therefore, statistical models are needed, and these can then provide exposure-response functions.

Clear changes in mortality could be caused by other factors than air pollution, e.g. it has been shown in several studies that influenza epidemics cause substantial excess deaths in the winter months when air pollution is also high. Therefore, inappropriate modelling of these influenza effects could bias the air pollution results, especially, if the timing of those epidemics is correlated with air pollution.

For example, Figure 22 shows the time series of death counts in Erfurt in Winter 1995/96. One can see a tall spike in late 1995 (around day 100).

In Figure 23 the so-called doctor's practice index for Winter 1995/96 is given, however, for the whole of Germany since only very few doctor's practices in Thuringia participated in the survey system. This index measures the average relative deviation of the observed acute respiratory activity from a background level which is determined for all doctor's practices which participate in the survey system. It can be clearly seen from Figure 23 that there was an influenza epidemic also in late 1995.

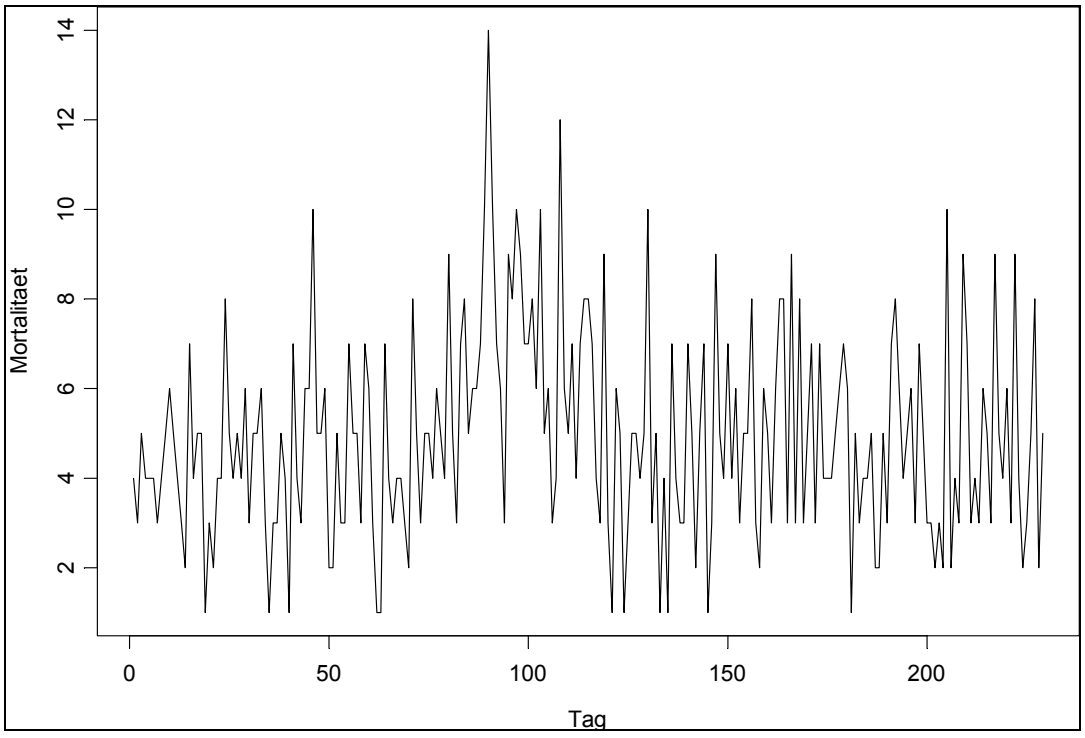

Figure 22 Time series of daily deaths in Erfurt, winter 1995/96

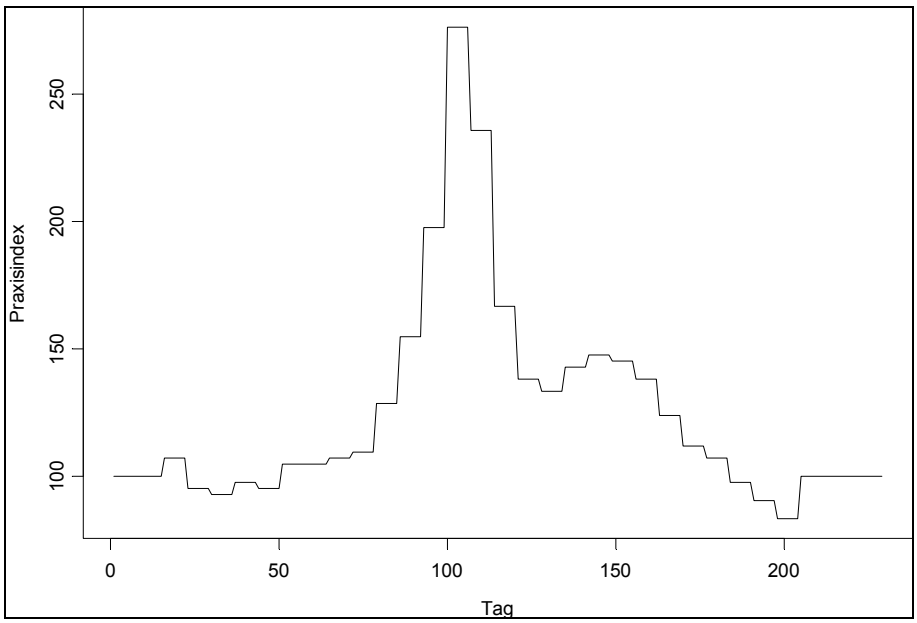

Figure 23 Doctor's practice index for winter 1995/96

To estimate the increase in risk for mortality associated with the influenza epidemic in winter 1995/96, a generalized additive Poisson regression model was fitted with a smooth function of the doctor's practice index. Lags of up to plus or minus three weeks were tested because the peak of an influenza epidemic may hit Erfurt at another date than Germany. The residuals of the mortality series, that means the difference between the observed death counts and the mortality values that are fitted after adjusting for the influenza effect, are shown in Figure 24. An inspection of these residuals reveals that after adjusting for the effect of the influenza epidemic, the clearly visible peak in late 1995 in Figure 22 4 is now much less pronounced.

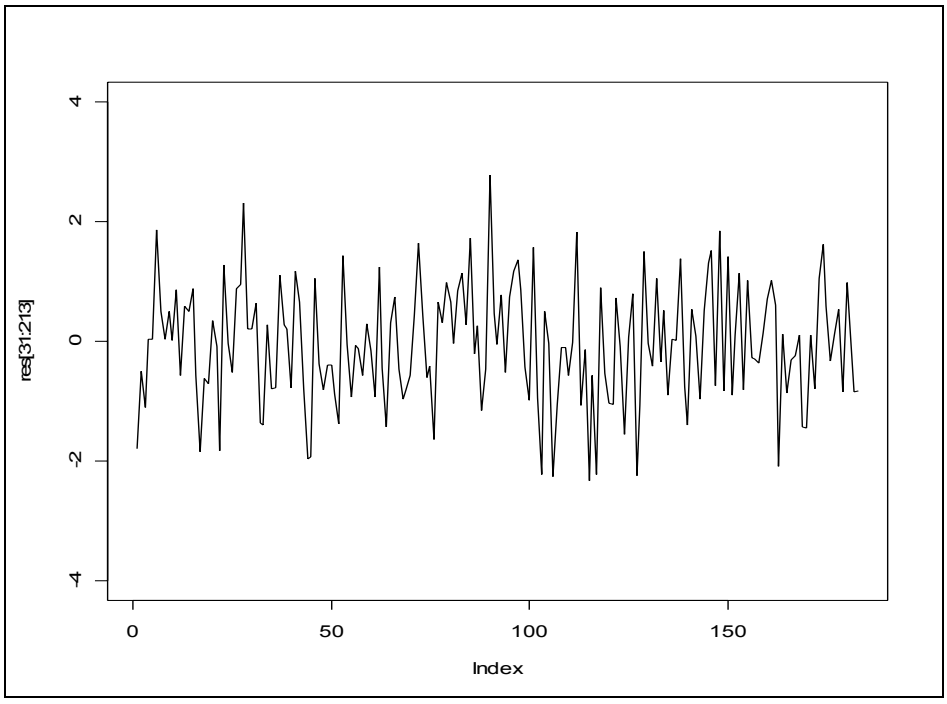

Figure 24 Residuals after control for epidemic, trend down, winter 1995/96

In conclusion the influence of concurrent change of other environmental, social or behavioral factors must be first allowed for before the health effects of air pollution can be quantified. The data needed for monitoring air pollution effects on health comprise air pollution variables, population health markers, other non-air pollution explanatory factors (confounders).

Therefore online monitoring of health effects of air pollution is impossible.

6.3 Annex C: Personal exposure and outdoor measurements

Nearly all ambient air-pollution studies have used ambient air monitoring data as surrogate for the exposure of the population or subgroup of interest. The reasons for the use of fixed ambient air monitors to estimate population short- and long-term exposure are that this approach has been successful, and most epidemiological studies require large populations and long exposure/effect follow-up times. Monitoring of individual exposures is too invasive and expensive to be applied for such purposes. However, since people spend up to 90% of their time indoors, the validity of using ambient concentrations as an accurate estimate of exposure has raised concerns because exposure misclassification could bias epidemiologic results.

To validate the results of the short-term studies (time-series, panel studies) the correlation between the day-to-day variation of outdoor levels and personal exposures should be determined. For long-term studies (cross-section, cohort studies), the cross-sectional association between outdoor levels and personal exposure is more relevant.

A number of studies have been undertaken to measure personal exposure directly using personal monitors, and to determine the correlations of personal exposure with outdoor concentrations. The correlations between personal exposure and ambient levels of air pollutants are in general influenced by following factors:

- indoor penetration of outdoor-generated air pollutants
- indoor sources of air pollutants under consideration
- time activity patterns of population (e.g. time spent indoors, close to traffic, at the work place)
- spatial variation in ambient air concentrations.

PM

Many studies have demonstrated that individual personal exposures to PM are poorly correlated with ambient concentrations (1-8). These poor correlations were initially used to argue that ambient PM is a poor surrogate for exposure to PM and to question the epidemiological conclusions (3, 9, 10). In response, Wilson et al. (11) and Mage et al. (12) argued that the seeming contradiction between the exposure studies and epidemiological findings is “a logical syllogism”. They argued that the composition and properties of ambient particles differ substantially from those generated in other microenvironments and that the epidemiological studies use central-site ambient PM as a surrogate for exposure to “PM of ambient origin”, not as a surrogate for total PM exposure. This argument is now supported by longitudinal exposure assessment studies of PM and specific PM components with repeated measures, which have found higher correlations between personal exposures and ambient concentrations. However, such studies have also identified substantial between-subject variability in personal ambient correlation coefficients, including some individuals with low correlations. Indoor monitoring and

activity data has indicated that much of this variability can be accounted for by indoor sources of particles and indoor– outdoor air exchange rates. However, the correlation that interests many epidemiologists is not that between *total* personal exposure and outdoor concentrations, but the correlation between *that component of personal exposure due to outdoor particles* and the outdoor concentrations. This requires the ability to estimate the contribution to personal exposures from particles originating outdoors. Only a few studies have reported making this attempt to characterize exposure to ambient and nonambient particles, to quantify exposure errors arising from the use of a central site surrogate, and to understand the effect of such errors on epidemiological conclusions.

One of such studies was recently published by Ebelt et al. (13). In this study a method for estimation of exposures to ambient and nonambient particles based on time-activity data and the use of particulate sulfate as a tracer for indoor infiltration of ambient particles was developed. The authors showed that the total fine particle exposures were dominated by exposures to nonambient particles, which were not correlated with ambient fine particle exposures or ambient concentrations. Although total and nonambient particle exposures were not associated with any of the health outcomes, ambient exposures (and to a lesser extent ambient concentrations) were associated with several adverse health effects. These results demonstrate the usefulness of separating total personal particle exposures into their ambient and nonambient components. The results support previous epidemiologic findings using ambient concentrations by demonstrating an association between health outcomes and ambient (outdoor origin) particle exposures but not with nonambient (indoor origin) particle exposures.

Gaseous pollutants

Only few studies have evaluated the short-term association between personal and ambient concentrations for other air-pollution components than PM (14, 15). In general, personal and ambient concentrations of NO_2, O_3 and SO_2 were poorly correlated. These results were not unexpected since measured personal gaseous exposures were frequently below the limits of detection. In addition, personal $PM_{2.5}$ and personal gaseous pollutant exposures were generally not correlated, whereas ambient gaseous concentrations were found to be strongly associated with personal $PM_{2.5}$ exposures. These results suggest that ambient gaseous concentrations for O_3, NO_2 and SO_2 are acting as surrogates, rather than confounders of $PM_{2.5}$ in the estimation of PM health effects.

The validity of fixed ambient air monitors as estimates of individual exposures in long-term studies (cross-section/cohort) is more difficult to assess. However, several personal exposure studies have investigated the short-term-cross-sectional associations, which may be extrapolated to long-term cross-sectional associations. Personal NO_2 exposures have been found to be only weakly to moderately correlated with outdoor levels in the presence of indoor

sources (16-19). Moreover, the within-community variability of NO_2 may be as large as or even larger than the variability across regions. It suggests, that central measurement sites may not well reflect population average exposure for such traffic related air pollutants. The linkage of spatially modeled air-pollution levels and geographically coded addresses of study subjects by use of Geographical Information System (GIS) is a promising approach. However, for NO_2 and CO measured in the EXPOLIS study, the cities with the highest outdoor levels also showed the highest personal exposure, and vice versa (20, 21).

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6.4 Annex D: Projects on health indicators

Advisory Group on the Medical Aspects of Air Pollution Episodes – Department of Health _ UK

http://www.dh.gov.uk/PublicationsAndStatistics/Publications/PublicationsPolicyAndGuidance/PublicationsPolicyAndGuidanceArticle/fs/en?CONTENT_ID=4102961&chk=7sE/3I

Proposed Indicators of the WHO Environmental Health Indicator Project

The group proposed ambient and health indicators and to combine to a health related air quality indicator, and to calculate life years lost (WHO/ECEH).

Environment and health information system (WHO/ECOEHIS)

ECOEHIS Objectives are to propose, validate and test for feasibility a set of 'core' environment and health indicators for EU countries; to become part of the European Community Health Monitoring System. ECOEHIS is co-sponsored by a grant from the European Commission DG SANCO Health Monitoring Programme (HMP)

ECOEHIS Implementation: Experts preparing and reviewing the proposals; Convening Working Group meetings; Testing the proposed indicators for feasibility in the Member States; Consultation with the Member States to approve the methodology.

Environment and health information system of the WHO/Regional office for Europe

WHO/ Europe has developed the EH indicator methodology in collaboration with several Member States and the EC DG SANCO. It involved multidisciplinary expertise on policy analysis, environmental health impact assessment as well as integration of different information sources. The activities carried out in intensive discussions at technical meetings and in consultation with participating Member States, comprise:

Selection of policy relevant environmental issues to enable a balanced and comprehensive picture of the most health-relevant problems, which are of straightforward utility for policy actions across Europe. The priority issues are identified following a review of the National Environmental Health Action Plans and recommendations of a multidisciplinary steering committee;

Crosscheck of proposed EH indicators **for compatibility** with the European Community Legislation and adjustment to the reporting obligations;

Development of **methodological guidelines** for generating the indicators and related assessment and reporting mechanisms;

Feasibility testing of the proposed methodology to 'opt' for a core set of EH indicators;

ENHIS

IMPLEMENTING ENVIRONMENT AND HEALTH INFORMATION

SYSTEM IN EUROPE (DG SANCO financed)

This project, coordinated by WHO and co-sponsored by the EC DG Sanco and the partner institutions from 11 Member States, aims to establish a comprehensive information and knowledge system (ENHIS) that will generate and analyze environmental health information to support relevant policies in Europe, focusing on children's health. The indicators relate to

relevant environmental health issues: air quality, housing and settlements, road accidents, noise, waste and contaminated landscape, radiation, water and sanitation, food safety, chemical accidents and occupational environment, interconnecting environmental risks, health determinants, effects on population health, and policies. The project is a continuation of an earlier pilot project (ECOHEIS), which was coordinated by WHO and which has produced a first set of indicator definitions, a database, a website and an indicator report.

The ENHIS project is organized in six tasks / work packages (WP) implemented under the responsibility of a project partner. They are as follows: *WP1:* Determine information needs of policies; *WP2*: Define and update core set of EH indicators; *WP3*: Develop methods for information generation from existing data sources and surveys; *WP4*: Provide technical support to national collaborating centres; *WP5*: Integrate health impact assessment, and *WP6*: Information maintenance, analysis and reporting.

ENHIS2

ENHIS2 - Establishment of Environmental Health Information System Supporting Policy Making

Michal KRZYZANOWSKI

http://europa.eu.int/comm/health/ph_projects/2004/action1/action1_2004_24_en.htm

HIS

Health Interview Surveys (HIS) represent an efficient source of information for presenting the use of medical services, such as:

- consultation of doctors/dentists: number of persons visiting a doctor and a dentist
- hospitalisation: number of persons who were hospitalised for less or more than one day
- preventive care: number of women who had a breast cancer test (mamography) or a cervical cancer test

These indicators are expressed as percentages within population layers defined by the background variables: sex, age group and activity status; respectively educational level. These percentages were not statistical adjusted for interacting effects between the background variables.

For the definition of the educational level, the ISCED classification was used. For some countries a mapping between a national coding system and the ISCED levels was defined. See also the document on background variables.

The data come from non-harmonised national surveys and the countries were asked to post-harmonise the data according to the guidelines described in guidelines_HIS_2004.

Geographical coverage:

The HIS data are available in more or less degree for all EU Member States (except Luxembourg) and for Bulgaria, Romania, Iceland, Norway and Switzerland.

The coverage is very diverse depending on the indicator. A tabular overview is given in coverage_by_country.

Time coverage

The HIS data are collected in different years depending on the country, going from 1996 to 2003. A tabular overview is given in HIS_2004_surveys (http://europa.eu.int/estatref/info/sdds/en/health/HIS_2004_surveys.pdf).

Periodicity

There is no fixed periodicity in these kinds of health surveys. Very few countries have a yearly survey on these topics. A tabular overview is given in HIS_2004_surveys.

Timeliness

The national surveys are not all performed in the same period and results are not all at the same time available.

6.5 Annex E: APHEIS I Guidelines

Outcome Data for Epidemiology

Aggregated data will be requested. The aggregating area will correspond, in each case, to the area covered by a monitoring system according to Annex VI of 1999/30/EC. The aggregating time will be 24 hours (calendar day).

The delay for data availability will be, whenever possible, one year.

The outcome data should be provided in electronic format.

It is proposed for the time being to keep the data collection to a minimum but some centres may be able to collect and process additional indicators.

The series requested will include (note that ICD codes below are given for the 9th revision; the correspondence with the 10th revision must be provided, if this revision is used).

Mortality data

Data on mortality will be recorded by age group and by cause of death. Three series of mortality will be analysed:

♦Total daily number of deaths (excluding deaths from external causes i.e. excluding those with ICD9≥800),

♦Respiratory (ICD9:460-519)

♦Cardiovascular (ICD9:390-459).

Three age groups will be considered: 15-64 years; 65-74 years; 75+ years and all ages.

The mortality data will generally be provided by Mortality Registers.

Morbidity data

Set of core health indicators to be collected by each centre:

♦Hospital Admissions Respiratory (ICD9 460-519)

♦Pneumonia and acute bronchitis hospital admissions (ICD9 466, 480-486)

♦Hospital Admissions Cardiac (ICD9 410-414, 427, 428).

Four age groups will be considered <15 Years, 15-64 Years, 65-74 Years, 75+ Years.

The hospital admission data provision will depend on the national collection system and will generally use the first discharge diagnosis.

Set of additional health indicators to be collected on a voluntary basis by the centres:

If emergency admissions (or good data on emergency visits) are available, they can be used instead or in addition to total admissions; codes as above.

If in a specific center, any other morbidity indicator is well defined and operational for a long time, then it may be used as an additional health indicator.

Confounders

To assess the short-term effects of air pollution, only confounders varying with time must be taken into account. For this purpose we need for every day:

– day of week

– if it is a holiday (bank, school)

– daily number of influenza admissions (ICD9 487) or other sources on influenza epidemics

– unusual events (strikes, etc.)

– sharp reduction of the population

– 24 hour average, minimum and maximum temperature (°C)

– 24 hour average relative humidity(%)

– 24 hour average dew point

– 24 hour average total pollen counts

Confounders on long-term relationships are factors associated with the studied outcomes and perhaps the exposure. If available, the most important, on an annual basis, are:

– population in the study area by sex and age in 5 years groups

– prevalence of chronic respiratory disease by sex and age in 5 years groups

– smoking prevalence by sex and age in 5 years groups

– occupational exposures (optional)

Effect Modifiers

It has been hypothesised that certain variables may act as effect modifiers in the air pollution health association. There is some recent evidence from the APHEA project and other studies that this maybe true.

The effect modifiers characterise an area and the associated population and may be classified in 5 categories:

➢Variables characterising the air pollution mix and levels such as: annual and seasonal level of each pollutant; the ratio of $PM_{2.5}/PM_{10}$, NO_2/PM_{10} and black smoke/PM_{10} (if available); correlation coefficients between different pollutants and between different monitoring sites for one pollutant.

➢Variables characterising the climate: annual and seasonal temperature and humidity.

➢Health status of the population on an annual basis: standardised mortality rate by sex and age in 5 year groups; and lung cancer mortality rate by sex and age in 5 year groups; COPD deaths by sex and age in 5 year groups; cardiovascular deaths by sex and age in 5 year groups; lung cancer incidence rates by sex and age in 5 year groups; percentage of persons over 65 years of age; smoking prevalence; unemployment rates; educational level; poverty rates.

➢Geographical area: a division in East/West and North/South; latitude-longitude.

➢Time-activity patterns of the population (how much time is spent indoors, outdoors and in different means of transportation).

There is probably no uniform source for the information in sections 3.6 and 3.7.

♦Meteorological parameters can be obtained from Observatories in each area.

♦The number of influenza admissions from the same Agency as the outcome series on respiratory admissions.

♦There is an existing, properly working European Aeroallergen Network (EAN), which could provide daily pollen data for APHEIS project. (http://www.univie.ac.at/ean/public),

♦EUROSTAT may also provide some of the data required (http://wwww.datashop.org-email:dslux@eurostat.datashop.lu).

Some of the confounders and effect modifiers mentioned above may not be readily available for the population needed and special care should be taken by the APHEIS centres when collecting this information.

6.6 Annex F: Questionnaire on health data availability

1

Questionnaire on health data availability

1 Contact information		
Name of your institution		
Address	Street	
	Town	
	Country	
	Website	
Name of contact person		
Email address		
Telephone number		

2 Health indicator: mortality data		
Is mortality data on a **daily** basis available?		
	Yes	
	No	
If not:		
Is daily mortality data available from another institution?		
	Yes	
	No	
Name of other institution		
Address	Street	
	Town	
	Country	
	Website	
Name of contact person		
Email address		
Telephone number		
If yes:		
For which regional resolution is the data available? (local or city, regional, national level)		
Can data be delivered in cause of death classes?		
	Yes	
	No	
What is the coding scheme?		
	ICD 9	
	ICD 10	
Can the data be delivered in age classes (i.e. total, 15-64, 65-74, 75+ years?)		
	Yes	
	No	
	Other:	
Is this data available on a routine basis?		
	Yes	Since (Year):
	No	
Is the data available as electronic file?		
	Yes	
	No	
What is the time lag for data availability? (e.g. data of Jan 2003 available in Jan 2005= time lag of 2 years)		
Years:		

2

3 Health indicator: Hospitalization data		
Is hospital admission data on a **daily** basis available?		
	Yes	
	No	
If not:		
Is daily hospital admission data available from another institution?		
	Yes	
	No	
Name of other institution		
Address	Street	
	Town	
	Country	
	Website	
Name of contact person		
Email address		
Telephone number		
If yes:		
For which regional resolution is the data available? (local or city, regional, national level)		
Are discharge diagnoses available (Of special interest are respiratory admissions ICD 9 460-519 as well as cardiovascular admissions ICD 390-459)		
	Yes	
	No	
What is the coding scheme?		
	ICD 9	
	ICD 10	
Can the data be delivered in age classes (i.e. total, 15-64, 65-74, 75+ years?)		
	Yes	
	No	
Are there separate data available for emergency and elective hospital admissions?		
	Yes	
	No	
Is this data available on a routine basis?		
	Yes	Since (Year):
	No	
Is the data available as electronic file?		
	Yes	
	No	
What is the time lag for data availability? (e.g. data of Jan 2003 available in Jan 2005= time lag of 2 years)		
Years:		

3

4 Health indicator: Children respiratory health			
Is data on respiratory infection of children (on a daily basis) available?			
	Yes		
	No		
If not:			
Is data on children respiratory infection available from another institution?			
	Yes		
	No		
Name of other institution			
Address	Street		
	Town		
	Country		
	Website		
Name of contact person			
Email address			
Telephone number			
If yes:			
For which regional resolution is the data available? (local or city, regional, national level)			
What is the coding scheme?			
	ICD 9		
	ICD 10		
Is this data available on a routine basis?			
	Yes	Since (Year):	
	No		
Is the data available as electronic file?			
	Yes		
	No		
What is the time lag for data availability? (e.g. data of Jan 2003 available in Jan 2005= time lag of 2 years)			
Years:			

4

5 Health indicator: Influenza epidemics			
Is influenza (on a daily basis) available?			
	Yes		
	No		
If not:			
Is influenza data available from another institution?			
	Yes		
	No		
Name of other institution			
Address	Street		
	Town		
	Country		
	Website		
Name of contact person			
Email address			
Telephone number			
If yes:			
For which regional resolution is the data available? (local or city, regional, national level)			
Is this data available on a routine basis?			
	Yes	Since (Year):	
	No		
Is the data available as electronic file?			
	Yes		
	No		
What is the time lag for data availability? (e.g. data of Jan 2003 available in Jan 2005= time lag of 2 years)			
Years:			

Please fill in the document electronically and fax or email to:

Dr. Stephanie von Klot, MPH
Research Unit Epidemiology of Air Pollution Health Effects
Institute of Epidemiology
GSF-National Research Center for Environment and Health
Ingolstaedter Landstr. 1
D-85758 Neuherberg
Germany

Phone: +49 (089)-3187-4563
Fax: +49 (089) 3187-3380
Email: klot@gsf.de
www.gsf.de/epi/air

Thank you for your collaboration! 

Questionnaire on air pollution health impact assessment (HIA)

1 Contact Information		
Name of your institution		
Address	Street	
	Town	
	Country	
	Website	
Name of Contact person		
Email address		
Telephone Number		

2 Does any organization in your country routinely assess **health effects of air pollution**?					
	Yes		If yes:	Regional level	
	No			National level	
If yes:					
Name of other institution					
Address	Street				
	Town				
	Country				
	Website				
Name of Contact person					
Email address					
Telephone Number					

3 Does any organization in your country routinely assess the **health impact of air pollution** ?					
	Yes		If yes:	Regional level	
	No			National level	
If yes:					
Name of other institution					
Address	Street				
	Town				
	Country				
	Website				
Name of Contact person					
Email address					
Telephone Number					

3 Is **daily mortality** routinely monitored in your country?		
	Yes	
	No	
If yes:		
Name of other institution		
Address	Street	
	Town	
	Country	
	Website	
Name of Contact person		
Email address		
Telephone Number		

Questionnaire on air pollution health impact assessment (HIA)

4 Is **daily hospital admission** routinely monitored in your country?		
	Yes	
	No	
If yes:		
Name of other institution		
Address	Street	
	Town	
	Country	
	Website	
Name of Contact person		
Email address		
Telephone Number		

5 Are respiratory infections in children routinely monitored in your country?		
	Yes	
	No	
If yes:		
Name of other institution		
Address	Street	
	Town	
	Country	
	Website	
Name of Contact person		
Email address		
Telephone Number		

Please fill in the document electronically and fax or email to:

Dr. Stephanie von Klot, MPH
Research Unit Epidemiology of Air Pollution Health Effects
Institute of Epidemiology
GSF-National Research Center for Environment and Health
Ingolstaedter Landstr. 1
D-85758 Neuherberg
Phone: +49 (089)-3187-4563
Fax: +49 (089) 3187-3380
Email: klot@gsf.de
www.gsf.de/epi/air

Thank you for your collaboration! ☺

6.8 Annex H: Returned questionnaires on health data availability

Mortality data	*Information obtained*
Country	Austria
Mortality data available on daily basis	yes
Name of Institution	STATISTIK AUSTRIA
Street	Guglgasse 13
City	A-1110 Wien
Website	www.statistik.at
Contact person	Barbara Leitner, Peter Bayer
Email Adress of Contact Person	peter.bayer@statistik.gv.at ; barbara.leitner@statistik.gv.at
Telephone Number	+43 1 71128-7262
Regional resolution	local
Cause of death classes available	yes
Coding Scheme ICD	ICD 10
Age classes available	yes
Mortality data available routinely	yes
Routinely available since	1970
Data as electronic file	yes
Time lag [Years]	1
Remarks	
Country	Belgium
Mortality data available on daily basis	yes
Name of Institution	SCIENTIFIC INSTITUTE OF PUBLIC HEALTH
Street	J. WYTSMANSTREET 14
City	BRUSSELS
Website	WWW.IPH.FGOV.BE/EPIDEMIO/spma/index.htm
Contact person	NATHALIE BOSSUYT
Email Adress of Contact Person	n.bossuyt@iph.fgov.be
Telephone Number	+32 2 6425407
Regional resolution	
Cause of death classes available	yes
Coding Scheme ICD	ICD 9
Age classes available	yes
Mortality data available routinely	yes
Routinely available since	1987
Data as electronic file	yes
Time lag [Years]	10
Remarks	we receive a update of the national register on a weekly basis, this is used to rapidly identify changes. The models allow to have a good estimate at the end of the second week
Country	Cyprus
Mortality data available on daily basis	yes
Name of Institution	Statistical Service of Cyprus
Street	Michalakis Karaolis
City	Nicosia
Website	www.mof.gov.cy/cystat
Contact person	Loukia Makri
Email Adress of Contact Person	lmakri@cystat.mof.gov.cy
Telephone Number	+357-22602150
Regional resolution	Local Level
Cause of death classes available	yes
Coding Scheme ICD	ICD 10
Age classes available	yes
Mortality data available routinely	yes
Routinely available since	1993
Data as electronic file	yes
Time lag [Years]	2
Remarks	ICD-10 for 2004/Eurostat 65 Causes shortlist for 2001-2003/ Condensed Mortality List 1 (ICD-10) for 1996-2000/ UN Adapted Mortality List for 1993-1995] . Available as electronic file 1999 onwards

Mortality data	*Information obtained*
Country	Czech Republic
Mortality data available on daily basis	yes
Name of Institution	Czech Statistical office
Street	Na padesátém 81
City	100 82 Praha 10
Website	www.czso.cz
Contact person	Terezie Kretschmerová
Email Adress of Contact Person	Terezie.kretschmerova@czso.cz
Telephone Number	+420 27405 4063
Regional resolution	NUTS 5
Cause of death classes available	yes
Coding Scheme ICD	ICD 10
Age classes available	yes
Mortality data available routinely	yes
Routinely available since	1919
Data as electronic file	yes
Time lag [Years]	1
Remarks	electronic file since 1993
Country	Denmark
Mortality data available on daily basis	yes
Name of Institution	Statistics Denmark
Street	Sejroegade 11
City	Copenhagen
Website	www.dst.dk
Contact person	Lisbeth Laursen
Email Adress of Contact Person	LIL@dst.dk
Telephone Number	+45 39 17 31 03
Regional resolution	
Cause of death classes available	yes
Coding Scheme ICD	ICD 10
Age classes available	missing
Mortality data available routinely	yes
Routinely available since	1994 before that ICD 8
Data as electronic file	yes
Time lag [Years]	4
Remarks	
Country	Estonia
Mortality data available on daily basis	yes
Name of Institution	Statistics Estonia
Street	Endla 15
City	Tallinn
Website	www.stat.ee
Contact person	Gleb Denissov
Email Adress of Contact Person	Gleb.denissov@stat.ee
Telephone Number	+372 6259224
Regional resolution	Local
Cause of death classes available	yes
Coding Scheme ICD	ICD 10
Age classes available	yes
Mortality data available routinely	yes
Routinely available since	1989
Data as electronic file	yes
Time lag [Years]	1
Remarks	

Mortality data	*Information obtained*
Country	Finland
Mortality data available on daily basis	yes
Name of Institution	Statistics Finland
Street	Työpajankatu 13
City	Helsinki
Website	http://stat.fi/
Contact person	Helena Korpi
Email Adress of Contact Person	helena.korpi@stat.fi
Telephone Number	+358-9-17343605
Regional resolution	
Cause of death classes available	yes
Coding Scheme ICD	ICD 10
Age classes available	yes
Mortality data available routinely	yes
Routinely available since	1969
Data as electronic file	yes
Time lag [Years]	2
Remarks	
Country	France
Mortality data available on daily basis	yes
Name of Institution	InVS
Street	12 rue du Val d'Osne
City	94415 Saint Maurice cedex
Website	http://www.invs.sante.fr/
Contact person	Sylvia Medina
Email Adress of Contact Person	s.medina@invs.sante.fr
Telephone Number	+ 33 1 41 79 67 56
Regional resolution	City if not too small, regional and national
Cause of death classes available	yes
Coding Scheme ICD	9 and 10
Age classes available	yes
Mortality data available routinely	yes
Routinely available since	1968 (ICD8) 1979 (ICD 9)
Data as electronic file	yes
Time lag [Years]	3
Remarks	
Country	Germany
Mortality data available on daily basis	yes
Name of Institution	Statistischen Landesämter der Länder (16x)
Street	Graurheindorfer Strasse 198
City	53117 Bonn
Website	www.destatis.de
Contact person	Torsten Schelhase
Email Adress of Contact Person	torsten.schelhase@destatis.de
Telephone Number	01888-644-8109
Regional resolution	Regional level: Bundesländer, NUTS-2-level, maybe Kreise
Cause of death classes available	yes
Coding Scheme ICD	ICD 10
Age classes available	yes
Mortality data available routinely	yes
Routinely available since	1950
Data as electronic file	yes
Time lag [Years]	2
Remarks	problem: confidentiality

Mortality data	*Information obtained*
Country	Ireland
Mortality data available on daily basis	yes
Name of Institution	Central Statistics Office
Street	Skehard Road
City	Cork
Website	www.cso.ie
Contact person	Joseph Keating
Email Adress of Contact Person	Joseph.Keating@cso.ie
Telephone Number	00 353 21 4535121
Regional resolution	County Level. Also some towns and cities
Cause of death classes available	yes
Coding Scheme ICD	ICD 9
Age classes available	yes
Mortality data available routinely	no
Routinely available since	
Data as electronic file	yes
Time lag [Years]	2
Remarks	subject to confidentiality issues
Country	Italy
Mortality data available on daily basis	yes
Name of Institution	ISTAT – National Institute of Statistics
Street	Via Cesare Balbo 16
City	Rome
Website	Via Cesare Balbo 16
Contact person	Antonella Ciccarese
Email Adress of Contact Person	Ciccaresstat.it
Telephone Number	00 39 06 4673 3282
Regional resolution	Municipality level. Warning: sometimes Istat can't provide mortality data by municipality level, if detailed by other variables too, because the low number of deaths in the tables cells.
Cause of death classes available	yes
Coding Scheme ICD	9 -2002 10 from 2003
Age classes available	yes
Mortality data available routinely	yes
Routinely available since	1969
Data as electronic file	yes
Time lag [Years]	3
Remarks	Mortality data available but information is not included in the disseminated "standard" file yet
Country	Latvia
Mortality data available on daily basis	yes
Name of Institution	Health statistics and medical technologies state agency
Street	Duntes street 12/22
City	Riga
Website	www.vsmta.lv
Contact person	Jautrite Karashkevica
Email Adress of Contact Person	jautrite@vsmta.lv
Telephone Number	+371 7501588
Regional resolution	District, city, regional and national level
Cause of death classes available	yes
Coding Scheme ICD	10
Age classes available	yes
Mortality data available routinely	yes
Routinely available since	1996
Data as electronic file	yes
Time lag [Years]	1
Remarks	

Mortality data	*Information obtained*
Country	Lithuania
Mortality data available on daily basis	yes
Name of Institution	Statistics Lithuania
Street	Gedimino ave. 29
City	Vilnius
Website	www.stat.gov.lt
Contact person	Liuda Kasparaviciene
Email Adress of Contact Person	liuda.kasparaviciene@stat.gov.lt
Telephone Number	+370 85 2 364 775
Regional resolution	National, regional, municipality level.
Cause of death classes available	yes
Coding Scheme ICD	ICD 10
Age classes available	yes
Mortality data available routinely	yes
Routinely available since	1994
Data as electronic file	yes
Time lag [Years]	1
Remarks	
Country	Luxembourg
Mortality data available on daily basis	yes
Name of Institution	Direction de la Santé
Street	Villa Louvigny – Allée Marconi
City	L-2120 Luxembourg
Website	www.ms.etat.lu/DIR_SANT/Index.htm
Contact person	Guy Weber
Email Adress of Contact Person	guy.weber@ms.etat.lu
Telephone Number	+ 352 478 55 71
Regional resolution	Published for national level
Cause of death classes available	missing
Coding Scheme ICD	ICD-IX between 1979 an 1997, ICD 10 thereafter
Age classes available	yes
Mortality data available routinely	yes
Routinely available since	1968
Data as electronic file	yes
Time lag [Years]	2
Remarks	published on a yearly basis, But writing an official demand to Health Ministry
Country	Malta
Mortality data available on daily basis	yes
Name of Institution	Department of Health
Street	95, GUARDAMANGIA HILL,
City	GUARDAMANGIA, MSD 08
Website	http://www.sahha.gov.mt/pages.aspx?page=41
Contact person	Dr. Kathleen England/ Dr. Frank Calleja
Email Adress of Contact Person	kathleen.grima@gov.mt frank.calleja@gov.mt
Telephone Number	(+356) 21237067
Regional resolution	local regional and national level
Cause of death classes available	yes
Coding Scheme ICD	ICD 9 - 1994 ICD 10 1995-
Age classes available	yes
Mortality data available routinely	yes
Routinely available since	1991
Data as electronic file	yes
Time lag [Years]	1
Remarks	

Mortality data	*Information obtained*
Country	Norway
Mortality data available on daily basis	yes
Name of Institution	Statistics Norway, Division for Health Statistics
Street	PO Box 8131 Dep
City	0033 Oslo
Website	ww.ssb.no
Contact person	Jens-Kristian Borgan
Email Adress of Contact Person	jens-kristian.borgan@ssb.no
Telephone Number	+4721094537
Regional resolution	Municipality of residence
Cause of death classes available	yes
Coding Scheme ICD	9 (1985-1995) 10 (1996-)
Age classes available	yes
Mortality data available routinely	yes
Routinely available since	1951
Data as electronic file	yes
Time lag [Years]	2
Remarks	
Country	Poland
Mortality data available on daily basis	yes
Name of Institution	CENTRAL STATISTICAL OFFICE of POLAND
Street	
City	
Website	www.stat.gov.pl
Contact person	Czarnecki Janusz
Email Adress of Contact Person	J.Czarnecki@stat.gov.pl
Telephone Number	
Regional resolution	All units of territorial division (from NUTS 0 to NUTS 5)
Cause of death classes available	yes
Coding Scheme ICD	ICD 10
Age classes available	yes
Mortality data available routinely	yes
Routinely available since	1999
Data as electronic file	yes
Time lag [Years]	2
Remarks	We register all deaths records in a one - year -process. … siehe Fragebogen … So that we could prepare them on a daily basis.
Country	Romania
Mortality data available on daily basis	missing
Name of Institution	Medical Documentation and Sanitary Statistics Cent
Street	9, Geare Vraca Street, Sector 1
City	Bucharest
Website	
Contact person	Dr. Dan Ursuleanu
Email Adress of Contact Person	dursulea@ms.ro, ipertach@ms.ro
Telephone Number	
Regional resolution	
Cause of death classes available	missing
Coding Scheme ICD	
Age classes available	missing
Mortality data available routinely	missing
Routinely available since	
Data as electronic file	missing
Time lag [Years]	-9
Remarks	

Mortality data	*Information obtained*
Country	SLOVENIA
Mortality data available on daily basis	yes
Name of Institution	Ministry of the Interior
Street	Adamic-Lundrovo nabrežje 2
City	1000 Ljubljana
Website	http://www.mnz.gov.si/index.php?id=2049&L=1
Contact person	Irena Tršinar
Email Adress of Contact Person	Irena.trsinar@gov.si
Telephone Number	
Regional resolution	local or city, regional, national level
Cause of death classes available	yes
Coding Scheme ICD	ICD 10
Age classes available	yes
Mortality data available routinely	yes
Routinely available since	1971
Data as electronic file	yes
Time lag [Years]	1
Remarks	
Country	Slovak Republic
Mortality data available on daily basis	yes
Name of Institution	Statistical Office of the Slovak Republic
Street	Mileticova 3
City	824 67 Bratislava
Website	www.statistics.sk
Contact person	Milan Žirko
Email Adress of Contact Person	milan.zirko@statistics.sk
Telephone Number	+421 02 50236771
Regional resolution	available for each municipality
Cause of death classes available	yes
Coding Scheme ICD	ICD 10 (since 1994)
Age classes available	yes
Mortality data available routinely	yes
Routinely available since	1996
Data as electronic file	yes
Time lag [Years]	1
Remarks	
Country	Sweden
Mortality data available on daily basis	yes
Name of Institution	National Board of Health and Welfare Centre for Epidemiology
Street	Rålambsvägen 3
City	118 53 Stockholm
Website	www.socialstyrelsen.se
Contact person	Charlotte Björkenstam
Email Adress of Contact Person	Charlotte.bjorkenstam@socialstyrelsen.se
Telephone Number	+46(8)-55 55 36 55
Regional resolution	local, national
Cause of death classes available	yes
Coding Scheme ICD	10
Age classes available	yes
Mortality data available routinely	yes
Routinely available since	1961
Data as electronic file	yes
Time lag [Years]	3
Remarks	

Mortality data	*Information obtained*
Country	Switzerland
Mortality data available on daily basis	yes
Name of Institution	Swiss Federal Statistical Office
Street	Espace de l'Europe 10
City	2010 Neuchatel
Website	www.bfs.admin.ch
Contact person	Dr. Christoph Junker
Email Adress of Contact Person	info@bfs.admin.ch
Telephone Number	christoph.junker@bfs.admin.ch
Regional resolution	local
Cause of death classes available	yes
Coding Scheme ICD	1969-1994 ICD 8, 1995- iCD10
Age classes available	yes
Mortality data available routinely	no
Routinely available since	
Data as electronic file	yes
Time lag [Years]	2
Remarks	This data exists, but is in principle only available in aggregated form, for reason of data protection.

Hospitalization data	*Information obtained*
Country	Belgium
Hospitalisation data available on daily basis	yes
Name of Institution	SPF Sécurité sociale
Street	Eurostation II - Place Victor Horta 40 bte 10
City	BRUSSELS
Website	
Contact person	Ingrid Mertens
Email Adress of Contact Person	Ingrid.Mertens@health.fgov.beFrancis.Loosen@health.fgov.be
Telephone Number	+32.2.524.86.43
Regional resolution	All Belgian hospitals
Discharge diagnoses available	yes
Coding Scheme ICD	ICD-9-CM
Age classes available	yes
emergency/elective admissions separable	yes
Hospitalization data available routinely	no
Routinely available since	
Data as electronic file	yes
Time lag [Years]	2
Remarks	discharge data are available
Country	Cyprus
Hospitalisation data available on daily basis	yes
Name of Institution	Statistical Service of Cyprus
Street	Michalakis Karaolis
City	Nicosia
Website	www.mof.gov.cy/cystat
Contact person	Loukia Makri
Email Adress of Contact Person	lmakri@cystat.mof.gov.cy
Telephone Number	+357-22602150
Regional resolution	Local level
Discharge diagnoses available	yes
Coding Scheme ICD	ICD 10
Age classes available	yes
emergency/elective admissions separable	no
Hospitalization data available routinely	yes
Routinely available since	1980
Data as electronic file	yes
Time lag [Years]	2
Remarks	public sector hospitals only; electronic file for the years 1995-2004
Country	Czech Republic
Hospitalisation data available on daily basis	yes
Name of Institution	Institute of Health Information and Statistics
Street	Palackeho nam. 4
City	P.O.Box 60, 128 01 Prague
Website	www.uzis.cz
Contact person	Zuzana Kamberská
Email Adress of Contact Person	kamberska@uzis.cz
Telephone Number	420 229 972 183
Regional resolution	Local
Discharge diagnoses available	yes
Coding Scheme ICD	ICD 10
Age classes available	yes
emergency/elective admissions separable	yes
Hospitalization data available routinely	yes
Routinely available since	1994
Data as electronic file	yes
Time lag [Years]	1
Remarks	

Hospitalization data	*Information obtained*
Country	Denmark
Hospitalisation data available on daily basis	yes
Name of Institution	Statistics Denmark
Street	Sejroegade 11
City	Copenhagen
Website	www.dst.dk
Contact person	Lisbeth Laursen
Email Adress of Contact Person	LIL@dst.dk
Telephone Number	+45 39 17 31 03
Regional resolution	
Discharge diagnoses available	yes
Coding Scheme ICD	ICD 10
Age classes available	missing
emergency/elective admissions separable	yes
Hospitalization data available routinely	.
Routinely available since	1994, before that ICD 8
Data as electronic file	yes
Time lag [Years]	2
Country	Finland
Hospitalisation data available on daily basis	yes
Name of Institution	National Research and Development Centre for Welfare and Health
Street	Lintulahdenkuja 5
City	00531 Helsinki
Website	www.stakes.fi
Contact person	Mika Gissler
Email Adress of Contact Person	mika.gissler@stakes.fi
Telephone Number	+358-9-3967 2279
Regional resolution	
Discharge diagnoses available	yes
Coding Scheme ICD	ICD 10: 1996 onwards (1987-1995 ICD 9)
Age classes available	yes
emergency/elective admissions separable	yes
Hospitalization data available routinely	yes
Routinely available since	1969
Data as electronic file	yes
Time lag [Years]	1
Remarks	
Country	France
Hospitalisation data available on daily basis	yes
Name of Institution	InVS
Street	12 rue du Val d'Osne
City	94415 Saint Maurice cedex
Website	http://www.invs.sante.fr/
Contact person	Sylvia Medina
Email Adress of Contact Person	s.medina@invs.sante.fr
Telephone Number	+ 33 1 41 79 67 56
Regional resolution	For public and some private hospitals at urban area level, for 9 urban areas in France : Bordeaux, Le Havre, Lille, Lyon, Marseille, Paris, Rouen, Strasbourg, Toulouse.
Discharge diagnoses available	yes
Coding Scheme ICD	10
Age classes available	yes
emergency/elective admissions separable	no
Hospitalization data available routinely	no
Routinely available since	Data available from approx. 2000 to 2003 (varies between urban areas)
Data as electronic file	yes
Time lag [Years]	2

Hospitalization data	Information obtained
Remarks	Programme de Surveillance Air & Santé - 9 villes PSAS-9
Country	Germany
Hospitalisation data available on daily basis	.
Name of Institution	Federal Statistical Office Germany
Street	
City	
Website	
Contact person	
Email Adress of Contact Person	
Telephone Number	
Regional resolution	
Discharge diagnoses available	yes
Coding Scheme ICD	ICD 10
Age classes available	yes
emergency/elective admissions separable	missing
Hospitalization data available routinely	no
Routinely available since	
Data as electronic file	yes
Time lag [Years]	2
Remarks	Not on a daily basis
Country	Ireland
Hospitalisation data available on daily basis	yes
Name of Institution	Department of Health and Children
Street	Hawkins Street
City	Dublin 2
Website	http://www.dohc.ie/
Contact person	Hugh Magee
Email Adress of Contact Person	hugh_magee@health.irlgov.ie
Telephone Number	00 353 01 - 635
Regional resolution	County Level
Discharge diagnoses available	yes
Coding Scheme ICD	ICD-10-AM from Jan 05
Age classes available	yes
emergency/elective admissions separable	yes
Hospitalization data available routinely	yes
Routinely available since	1994
Data as electronic file	yes
Time lag [Years]	1
Remarks	ICD-9-CM (Clinical modification) until end 2004
Country	Italy
Hospitalisation data available on daily basis	yes
Name of Institution	Ministry of Health
Street	Piazzale dell'Industria 20
City	Rome
Website	www.ministerosalute.it
Contact person	Mrs. Lucia Lispi
Email Adress of Contact Person	l.lispi@sanita.it
Telephone Number	0039 06 5994 2055
Regional resolution	Municipality
Discharge diagnoses available	yes
Coding Scheme ICD	ICD9CM
Age classes available	yes
emergency/elective admissions separable	yes
Hospitalization data available routinely	yes
Routinely available since	1999
Data as electronic file	yes
Time lag [Years]	2

Hospitalization data	Information obtained
Remarks	data is on discharges and not on admissions / Zu h_a_years: 1995 but good quality data is available since 1999 / Zu h_lag: 1,5 years.
Country	Latvia
Hospitalisation data available on daily basis	yes
Name of Institution	Health statistics and medical technologies state agency
Street	Duntes street 12/22
City	Riga
Website	www.vsmta.lv
Contact person	Jautrite Karashkevica
Email Adress of Contact Person	jautrite@vsmta.lv
Telephone Number	+371 7501588
Regional resolution	District, city, regional and national level
Discharge diagnoses available	yes
Coding Scheme ICD	10
Age classes available	yes
emergency/elective admissions separable	no
Hospitalization data available routinely	yes
Routinely available since	1991
Data as electronic file	19
Time lag [Years]	1
Remarks	
Country	Lithuania
Hospitalisation data available on daily basis	no
Name of Institution	Lithuanian Health Information Centre
Street	
City	Vilnius
Website	http://www.lsic.lt/html/en/lhic.htm
Contact person	Aldona Gaizauskiene, PhD, M.D.
Email Adress of Contact Person	aldona@lsic.lt
Telephone Number	(+370) 5 2773301
Regional resolution	
Discharge diagnoses available	N/A
Coding Scheme ICD	
Age classes available	N/A
emergency/elective admissions separable	N/A
Hospitalization data available routinely	N/A
Routinely available since	
Data as electronic file	N/A
Time lag [Years]	-9
Remarks	
Country	Malta
Hospitalisation data available on daily basis	yes
Name of Institution	Data Management Unit, St. Luke's Hospital
Street	G'Mangia Hill,
City	G'Mangia
Website	
Contact person	Dr. Alexandra Distefano
Email Adress of Contact Person	alexandra.distefano@gov.mt
Telephone Number	00 356 25951292
Regional resolution	Local and national
Discharge diagnoses available	yes
Coding Scheme ICD	ICD9/10
Age classes available	yes
emergency/elective admissions separable	yes
Hospitalization data available routinely	yes
Routinely available since	2005
Data as electronic file	yes

Hospitalization data	Information obtained
Time lag [Years]	1
Remarks	Only for stat hospital on the island Gozo
Country	Norway
Hospitalisation data available on daily basis	yes
Name of Institution	Statistics Norway, Division for Health Statistics
Street	PO Box 8131 Dep
City	0033 Oslo
Website	ww.ssb.no
Contact person	Jens-Kristian Borgan
Email Adress of Contact Person	jens-kristian.borgan@ssb.no
Telephone Number	+4721094537
Regional resolution	Municipality of residence
Discharge diagnoses available	yes
Coding Scheme ICD	9 (1988-1998) 10 (1999-)
Age classes available	yes
emergency/elective admissions separable	yes
Hospitalization data available routinely	yes
Routinely available since	1988
Data as electronic file	yes
Time lag [Years]	1
Remarks	Maybe also Norwegian Patient Register
Country	Poland
Hospitalisation data available on daily basis	yes
Name of Institution	Medical Statistics - National Institute of Hygiene
Street	Chocimska 24
City	Warszawa
Website	www.pzh.gov.pl
Contact person	Dr. Pawel Gorynski
Email Adress of Contact Person	pawel@medstat.waw.pl
Telephone Number	+48 22 5421236
Regional resolution	
Discharge diagnoses available	yes
Coding Scheme ICD	ICD 10
Age classes available	yes
emergency/elective admissions separable	yes
Hospitalization data available routinely	yes
Routinely available since	2003
Data as electronic file	yes
Time lag [Years]	2
Remarks	data for internal use only
Country	SLOVENIA
Hospitalisation data available on daily basis	yes
Name of Institution	Institute of Public Health
Street	Trubarjeva 2
City	1000 Ljubljana
Website	http://www.ivz.si
Contact person	Ada Hocevar Grom
Email Adress of Contact Person	Ada.Hocevar@ivz-rs.si
Telephone Number	+386 1 2441-426
Regional resolution	for communes and on regional level
Discharge diagnoses available	yes
Coding Scheme ICD	ICD 10
Age classes available	yes
emergency/elective admissions separable	yes
Hospitalization data available routinely	yes
Routinely available since	for emergency only1997
Data as electronic file	yes

Hospitalization data	Information obtained
Time lag [Years]	1
Remarks	data on routine basis only for emergency visits.
Country	Sweden
Hospitalisation data available on daily basis	yes
Name of Institution	National Board of Health and Welfare
Street	Rålambsvägen
City	Stockholm
Website	www.socialstyrelsen.se
Contact person	Petra Otterblad Olausson
Email Adress of Contact Person	petra.otterblad.olausson@soscialstyrelsen.se
Telephone Number	+46-8-555 530 00
Regional resolution	local, national
Discharge diagnoses available	yes
Coding Scheme ICD	10
Age classes available	yes
emergency/elective admissions separable	yes
Hospitalization data available routinely	yes
Routinely available since	1964
Data as electronic file	yes
Time lag [Years]	2
Remarks	Swedish Hospital Discharge Register
Country	Switzerland
Hospitalisation data available on daily basis	yes
Name of Institution	Swiss Federal Statistical Office
Street	Espace de l'Europe 10
City	2010 Neuchatel
Website	www.bfs.admin.ch
Contact person	Patrick Schwab
Email Adress of Contact Person	Patrick.Schwab@bfs.admin.ch
Telephone Number	+41 32 713 64 28
Regional resolution	place of residence: 600 regions
Discharge diagnoses available	yes
Coding Scheme ICD	ICD 10
Age classes available	yes
emergency/elective admissions separable	yes
Hospitalization data available routinely	no
Routinely available since	
Data as electronic file	yes
Time lag [Years]	2
Remarks	Data exists, but single cases are not delivered outside the SFSO for the reason of data protection.Aggregated data can be delivered, but cells with less than 3 cases will not be.

Children respiratory health data	*Information obtained*
Country	Cyprus
children respiratory health data available	yes
Name of Institution	Statistical Service of Cyprus
Street	Michalakis Karaolis
City	Nicosia
Website	www.mof.gov.cy/cystat
Contact person	Loukia Makri
Email Adress of Contact Person	lmakri@cystat.mof.gov.cy
Telephone Number	+357-22602150
Regional resolution	Local
Coding Scheme ICD	ICD 10
Children respiratory data available routinely	yes
Routinely available since	1980
Data as electronic file	yes
Time lag [Years]	2
Remarks	for public sector health institutions – discharges and out-patient attendances] Electronic file for the years 1995-2004
Country	Czech Republic
children respiratory health data available	yes
Name of Institution	National Institute of Public Health
Street	Srobarova 48
City	Praha 10
Website	www.szu.cz
Contact person	Cestmír Benes
Email Adress of Contact Person	cesta@szu.cz
Telephone Number	+420 26708 2487
Regional resolution	NUTS4 - discrits
Coding Scheme ICD	ICD 10
Children respiratory data available routinely	yes
Routinely available since	1993
Data as electronic file	yes
Time lag [Years]	0
Remarks	Zu crh_yn: weekly
Country	Estonia
children respiratory health data available	yes
Name of Institution	Health Protection Inspectorate
Street	Paldiski mnt. 81
City	Tallinn
Website	http://www.tervisekaitse.ee
Contact person	
Email Adress of Contact Person	kesk@tervisekaitse.ee
Telephone Number	6943500
Regional resolution	regional, national level
Coding Scheme ICD	ICD 10
Children respiratory data available routinely	missing
Routinely available since	
Data as electronic file	missing
Time lag [Years]	-9
Remarks	weekly

Children respiratory health data	*Information obtained*
Country	France
children respiratory health data available	yes
Name of Institution	GROG
Street	67 rue du Poteau
City	75018 Paris
Website	(http://www.grog.org/cgi-files/db.cgi?action=bulletin_vrs)
Contact person	Dr. Jean Marie Cohen, Dr Anne Mosnier
Email Adress of Contact Person	coordnat@grog.org
Telephone Number	+33156555151
Regional resolution	
Coding Scheme ICD	
Children respiratory data available routinely	missing
Routinely available since	2000 to 2003 (siehe Bemerkung)
Data as electronic file	missing
Time lag [Years]	-9
Remarks	sentinel network from GROG about bronchiolitis in children < 2 yrs.
Country	Germany
children respiratory health data available	.
Name of Institution	Federal Statistical Office Germany
Street	
City	
Website	
Contact person	
Email Adress of Contact Person	
Telephone Number	
Regional resolution	Reg. Level Bundesl: , NUTS-2-level, maybe Kreise
Coding Scheme ICD	ICD 10
Children respiratory data available routinely	no
Routinely available since	
Data as electronic file	yes
Time lag [Years]	2
Remarks	not on a daily basis
Country	Italy
children respiratory health data available	missing
Name of Institution	Ministry of Health
Street	Piazzale dell'Industria 20
City	Rome
Website	www.ministerosalute.it
Contact person	Mrs. Miriam Di Cesare
Email Adress of Contact Person	m.dicesare@sanita.it
Telephone Number	0039 06 5994 2515
Regional resolution	
Coding Scheme ICD	
Children respiratory data available routinely	missing
Routinely available since	
Data as electronic file	missing
Time lag [Years]	-9
Remarks	

Children respiratory health data	*Information obtained*
Country	Latvia
children respiratory health data available	yes
Name of Institution	Health statistics and medical technologies state agency
Street	Duntes street 12/22
City	Riga
Website	www.vsmta.lv
Contact person	Jautrite Karashkevica
Email Adress of Contact Person	jautrite@vsmta.lv
Telephone Number	+371 7501588
Regional resolution	National Level
Coding Scheme ICD	10
Children respiratory data available routinely	yes
Routinely available since	1992
Data as electronic file	yes
Time lag [Years]	1
Remarks	
Country	Malta
children respiratory health data available	yes
Name of Institution	Data Management Unit, St. Luke's Hospital
Street	G'Mangia Hill,
City	G'Mangia
Website	
Contact person	Dr. Alexandra Distefano
Email Adress of Contact Person	alexandra.distefano@gov.mt
Telephone Number	00 356 25951292
Regional resolution	Local and national
Coding Scheme ICD	ICD9/10
Children respiratory data available routinely	yes
Routinely available since	2005
Data as electronic file	yes
Time lag [Years]	1
Remarks	for hospital admissions in Gozo

Influenza data	*Information obtained*
Country	Belgium
Influenza data available	yes
Name of Institution	National Influenza Centre
Street	
City	
Website	www.iph.fgov.be/flu/
Contact person	Dr Fernande Yane
Email Adress of Contact Person	f.yane@iph.fgov.be
Telephone Number	+32 2 642 50 70
Regional resolution	National level
Influenza data available routinely	yes
Routinely available since	2001
Data as electronic file	yes
Time lag [Years]	-9
Remarks	surveillance, not full year, weekly data
Country	Cyprus
Influenza data available	yes
Name of Institution	Statistical Service of Cyprus
Street	Michalakis Karaolis
City	Nicosia
Website	www.mof.gov.cy/cystat
Contact person	Loukia Makri
Email Adress of Contact Person	lmakri@cystat.mof.gov.cy
Telephone Number	+357-22602150
Regional resolution	Local Level
Influenza data available routinely	yes
Routinely available since	1980
Data as electronic file	yes
Time lag [Years]	2
Remarks	
Country	Czech Republic
Influenza data available	yes
Name of Institution	National Institute of Public Health
Street	Srobarova 48
City	Praha 10
Website	www.szu.cz
Contact person	Cestmír Benes
Email Adress of Contact Person	cesta@szu.cz
Telephone Number	+420 26708 2487
Regional resolution	NUTS4
Influenza data available routinely	yes
Routinely available since	1993
Data as electronic file	yes
Time lag [Years]	0
Remarks	

Influenza data	*Information obtained*
Country	Denmark
Influenza data available	yes
Name of Institution	Statens Serum Institut
Street	
City	
Website	www.ssi.dk
Contact person	
Email Adress of Contact Person	
Telephone Number	
Regional resolution	
Influenza data available routinely	missing
Routinely available since	
Data as electronic file	missing
Time lag [Years]	-9
Remarks	
Country	Estonia
Influenza data available	yes
Name of Institution	Health Protection Inspectorate
Street	Paldiski mnt. 81
City	Tallinn
Website	http://www.tervisekaitse.ee
Contact person	
Email Adress of Contact Person	kesk@tervisekaitse.ee
Telephone Number	6943500
Regional resolution	regional, national level
Influenza data available routinely	missing
Routinely available since	
Data as electronic file	missing
Time lag [Years]	-9
Remarks	weekly
Country	Finland
Influenza data available	yes
Name of Institution	National Public Health Institute
Street	Mannerheimintie 166
City	FI-00300 Helsinki
Website	www.ktl.fi
Contact person	Petri Ruutu
Email Adress of Contact Person	Petri.ruutu@ktl.fi
Telephone Number	+358947448670
Regional resolution	Regional, national (laboratory confirmed only)
Influenza data available routinely	yes
Routinely available since	1995
Data as electronic file	yes
Time lag [Years]	-9
Remarks	

Influenza data	*Information obtained*
Country	France
Influenza data available	yes
Name of Institution	GROG Open Rome
Street	67 rue du Poteau
City	75018 Paris
Website	http://www.grog.org/
Contact person	Dr. Jean Marie Cohen, Dr Anne Mosnier
Email Adress of Contact Person	coordnat@grog.org
Telephone Number	+33156555151
Regional resolution	
Influenza data available routinely	missing
Routinely available since	
Data as electronic file	missing
Time lag [Years]	-9
Remarks	
Country	Germany
Influenza data available	yes
Name of Institution	Abteilung für Infektionsepidemiologie - Robert-Koch-Institut
Street	Seestr. 10
City	13353 Berlin
Website	http://influenza.rki.de/; http://www3.rki.de/SurvStat/ ;
Contact person	Dr. Karl Schenkel, M.Sc.
Email Adress of Contact Person	schenkelk@rki.de
Telephone Number	0049/30/4547-3911
Regional resolution	
Influenza data available routinely	yes
Routinely available since	
Data as electronic file	yes
Time lag [Years]	0
Remarks	weekly
Country	Italy
Influenza data available	missing
Name of Institution	Ministry of Health
Street	Viale della Civiltà Romana 7
City	Rome
Website	www.ministerosalute.it
Contact person	Ms. Maria Grazia Pompa
Email Adress of Contact Person	m.pompa@sanita.it
Telephone Number	0039 06 5994 3905
Regional resolution	
Influenza data available routinely	missing
Routinely available since	
Data as electronic file	missing
Time lag [Years]	-9
Remarks	data maybe at Ministry of health

Influenza data	*Information obtained*
Country	Latvia
Influenza data available	yes
Name of Institution	Health statistics and medical technologies state agency
Street	Duntes street 12/22
City	Riga
Website	www.vsmta.lv
Contact person	Jautrite Karashkevica
Email Adress of Contact Person	jautrite@vsmta.lv
Telephone Number	+371 7501588
Regional resolution	National Level
Influenza data available routinely	yes
Routinely available since	1993
Data as electronic file	yes
Time lag [Years]	1
Remarks	
Country	Lithuania
Influenza data available	yes
Name of Institution	Centre for communicable diseases prevention and control
Street	Kalvariju 153
City	Vilnius
Website	
Contact person	Gražina Mirinaviciute
Email Adress of Contact Person	g.mirinaviciute@ulpkc.lt
Telephone Number	+370 52159273
Regional resolution	local or city, regional, national level
Influenza data available routinely	no
Routinely available since	
Data as electronic file	yes
Time lag [Years]	-9
Remarks	only weekly during influenza epidemics
Country	Luxembourg
Influenza data available	yes
Name of Institution	Laboratoire National de la Santé – Laboratoire de Virologie
Street	42, rue du Laboratoire
City	L-1911 Luxembourg
Website	www.ms.etat.lu/MIN_SANT/Publication/Grippe/index.htm
Contact person	Mathias Opp
Email Adress of Contact Person	matthias.opp@lns.etat.lu
Telephone Number	+ 352 491 191 383
Regional resolution	National level
Influenza data available routinely	yes
Routinely available since	2003
Data as electronic file	yes
Time lag [Years]	-9
Remarks	Weekly reporting from week 40 to week 20

Influenza data	*Information obtained*
Country	Malta
Influenza data available	yes
Name of Institution	DISEASE SURVEILLANCE UNIT, DEPARTMENT OF PUBLIC HEALTH
Street	37/39 RUE D'ARGENS
City	MSIDA
Website	http://www.health.gov.mt/dsu/
Contact person	Dr. Tanya Mellilo Fenech
Email Adress of Contact Person	tanya.melillo@gov.mt
Telephone Number	(+356) 21332235
Regional resolution	NATIONAL
Influenza data available routinely	yes
Routinely available since	2002
Data as electronic file	yes
Time lag [Years]	0
Remarks	on a weekly basis
Country	Norway
Influenza data available	yes
Name of Institution	Norwgian Institute of Public Health
Street	P.O. Box 4404 Nydalen
City	N-0403 Oslo
Website	www.fhi.no
Contact person	Olav Hungnes
Email Adress of Contact Person	olav.hungnes@fhi.no
Telephone Number	+47 23402520
Regional resolution	national, county
Influenza data available routinely	yes
Routinely available since	1988
Data as electronic file	yes
Time lag [Years]	0
Remarks	
Country	Poland
Influenza data available	yes
Name of Institution	National Influenza Center - National Institute of Hygiene
Street	Chocimska 24
City	Warsaw
Website	www.pzh.gov.pl
Contact person	Miroslaw Czarkowski
Email Adress of Contact Person	Mpc@pzh.gov.pl
Telephone Number	48 022 542 12 10
Regional resolution	
Influenza data available routinely	yes
Routinely available since	
Data as electronic file	yes
Time lag [Years]	0
Remarks	weekly (from October to April) or biweekly (from May to September) reports

Influenza data	*Information obtained*
Country	Sweden
Influenza data available	yes
Name of Institution	Smittskyddsinstitutet
Street	Tomtebodavägen
City	Solna
Website	www.smittskyddsinstitutet.se
Contact person	
Email Adress of Contact Person	smi@smi.ki.se
Telephone Number	+46-8-457 23 00
Regional resolution	
Influenza data available routinely	missing
Routinely available since	
Data as electronic file	missing
Time lag [Years]	-9
Remarks	
Country	Switzerland
Influenza data available	yes
Name of Institution	Swiss Federal Office of Public Health
Street	
City	3003 Bern
Website	www.bag.admin.ch/sentinella/influenza/d/index.htm
Contact person	Mark Witschi
Email Adress of Contact Person	mark.witschi@bag.admin.ch
Telephone Number	+41 31 3231339
Regional resolution	national level
Influenza data available routinely	yes
Routinely available since	1987
Data as electronic file	yes
Time lag [Years]	1
Remarks	weekly

6.9 Annex I: APHEIS Guidelines for HIA

Data collection

In order to assess the impact of air pollution on outcomes (e.g. deaths, hospital admissions, asthma cases) in the target population for one year, the annual distribution of air pollution in different categories of exposure, the annual proportion of the target population in the exposure categories and the annual frequency of the outcomes are required in addition to the effect estimates derived from epidemiologic studies.

Population data

Demographic data in the target population (according to the APHEA2 protocol) should be obtained e.g. from the health data provider or the appropriate European agency: total number of population as well as gender distributed (man, woman) in 5 yr. age groups (Table 1) in order to be able to calculate age standardised mortality rates to a Standard European Population (Table 2).

Data should be based on the last census year or on yearly basis. Source of the data should be specified; if more than one exists (with possibly different information), the choice should be justified and the possible influence of the choice on the impact assessment should be considered in the sensitivity analysis. Mean numbers for 3-5 years can be considered as in the APHEA2 project.

The selected method of population enumeration should be clearly defined and recorded in each centre. In big centres where relative risks for infant mortality may be calculated, annual number of live births and background infant mortality will be needed to make HIA. Even if only some age groups will be of a particular interest for different health outcomes according to the existing scientific evidence, and will be considered in the data analysis, this information is important for standardisation.

The age-specific and age-standardised mortality rates will be used in comparisons between populations and interpretation of impact assessment estimates. Any possible restrictions of the target population should be identified (e.g. admission to hospital restricted to people with certain insurance plan or a possibility to use of hospitals outside the surveillance area by a part of target population).

Health and effect modifiers data

Health and effect modifiers data as defined by the Epi AG, have to take into account the needs for HIA, that is the annual proportion of the target population in the exposure categories and the annual frequency of the outcomes, in addition to the effect estimates derived from pooled analysis or epidemiological studies.

Health data

At present, the set of core health outcomes considered and some of the additional ones, proposed by the Epi AG and also by AirQ, can constitute the list of possible health events to examine in relation with air pollution. If a health outcome can occur several times per year in one subject (e.g. hospitalisation due to exacerbation of COPD symptoms), each case should be recorded.

For HIA purposes, the underlying incidence of health event X in the target population is needed. If an effect modifier has been identified (e.g. age group) – the incidence for each level of the effect modifier will be necessary.

The number of cases of the outcome X (annual) in the target population should be collected. For each outcome, the following should be specified:

- Number of cases in the current year
- Number of cases in each of the previous 3 years
- Source of data
- Reference for methodology of registration of the health data of concern
- Possible sources of uncertainty in the data (e.g. registration of cases from outside of target population).

If the health outcome data for a given target population is not available, background incidence in an outside population should be identified. As a first approximation, the value from AirQ can be used. The possible bias should be discussed. If the local frequency of the health outcome differs significantly from that observed in epidemiological studies used for derivation of the pollution-health relationship, it is possible that the definition of the health outcome indicator is different. Estimation of health impact using this indicator should then be critically evaluated and the decision might be taken to omit this indicator from the estimated set.

6.10 Annex J: Analysis of spatial site density and site population ratio

It is striking that the distinction between agglomerations and other zones which at first glance would be expected to be very important due to the large differences in population densities and pollution sources that may occur, merely plays a role with respect to those compounds for which an alert threshold has been defined. Essentially, the requirements regarding the assessment procedures and number of measurement sites are identical for all zones (with the exception for SO_2 and NO_2 mentioned).

Nevertheless, the rules shown in Figure 6 will result in a measurement network of gradually increasing density in zones with higher population density because with increasing population density a smaller area is needed to reach the higher population numbers which in turn lead to an increase of the number of sites.

This is illustrated in Figure 25 where the minimum measurement site density (no. of sites per km²) has been computed as function of population density under variation of the zone area (using the rules for APs regulated in the 1st Daughter Directive for a zone with previous levels above the UAT). Obviously, for a given zone area (e.g. 1,000 km², light blue curve in Figure 25) the site density is increasing with population density from ca. 1 site/1,000 km² (for 100 inhabitants/km²) up to 10 sites/1,000 km² (for 10,000 inhabitants/km²). Therefore, to asses the air quality of a moderately populated zone less monitoring stations would be required than for a heavy populated agglomeration having the same zone area.

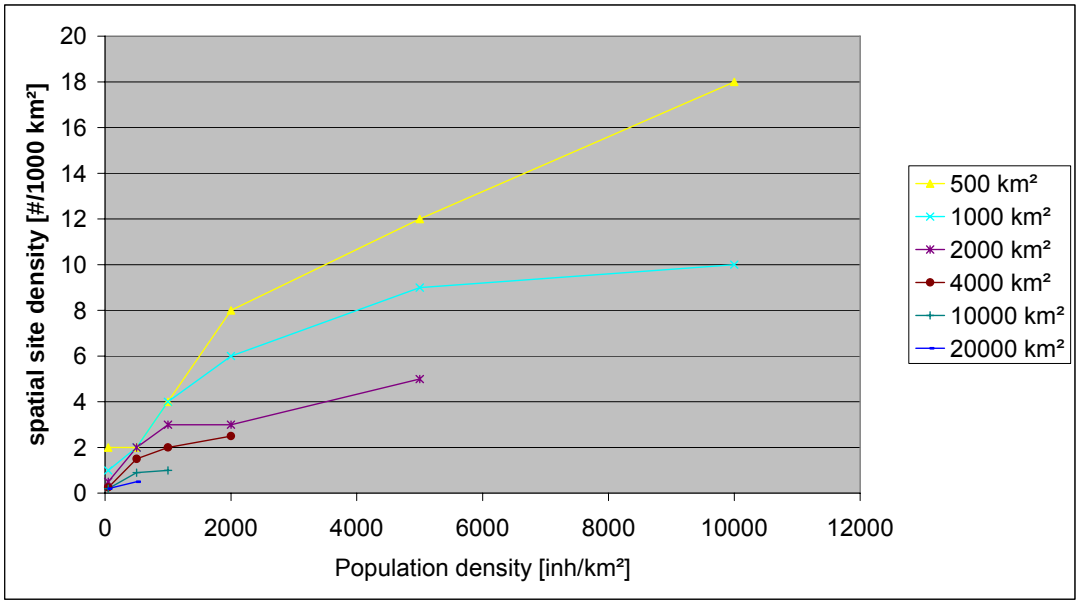


Figure 25 Spatial measurement site density as a function of mean population density and zone area[15]

However, the relation between spatial site density and population density clearly is sub-proportional and heavily dependent on the zone area.

This causes a **decrease** of site-population ratio with increasing population density (Figure 26). This effect can already be seen in the example given before if the number of inhabitants represented by the measurement sites is calculated. At the low population density level of 100

[15] according to the rules of the first Daughter Directive for zones with levels > UAT for zone areas between 500 and 20,000 km², stop value for calculation: 10 million inhabitants/zone

inh./km² one site is required for the overall 100,000 inhabitants, whereas the similar sized zone with higher population density has 10 million inhabitants and the ratio is only 1 site per 1 million inhabitants.

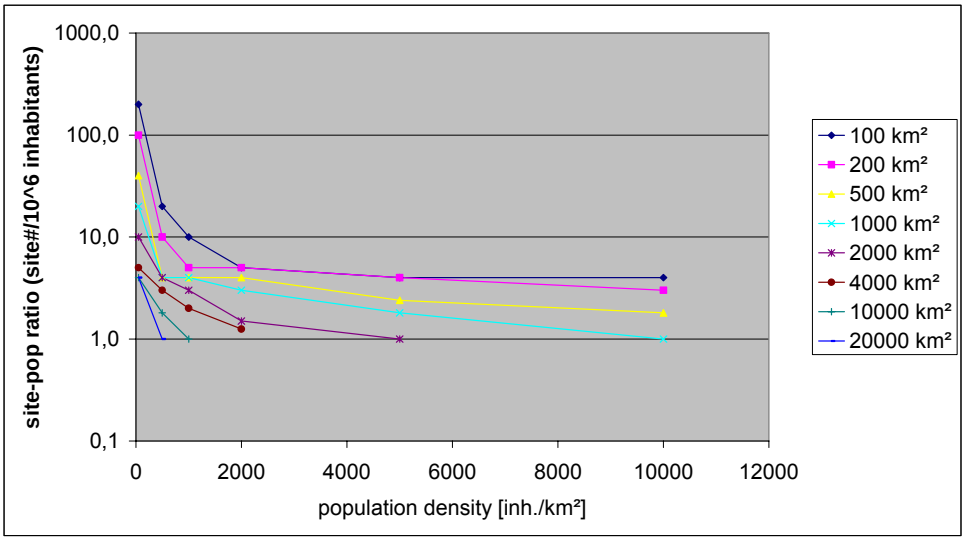


Figure 26 Site-Population ratio as a function of mean population density and zone area[16]

As a result, from the minimum requirements set in the EU directives it follows that

1. the **spatial** site density

- increases with population density, and this increase is more pronounced as long as the population density is quite low and/or the zone area is quite small
- is lower in large area zones than in small area zones of comparable population density

2. the **site-population ratio**

- decreases with growing population density
- is generally higher for small zones than for large ones

Apparently, the requirements on site numbers set in the air quality directives seem to contradict with the expectation that the air quality should be measured more intensely the more people might be exposed to air pollutants. However, it must be noted that the analysis presented before only considers the minimum requirements set in the Directives. It is quite probable that in many or most cases Member States exceed these minimum requirements and operate measurement networks that might be more suitable to reflect the exposure of the population.

[16] according to the rules of the first Daughter Directive for zones with levels > UAT for zone areas between 100 and 20,000 km², stop value for calculation: 10 million inhabitants/zone

6.11 Annex K: Evaluation of zoning information

6.11.1 Comparison of available databases

The combination of the information provided within the air quality quests and AirBase is necessary in order to determine the spatial and population related representativeness of the measurement sites. While the air quality quests contain e.g. information on the zones (including population and area) and the compounds measured at those sites used for the air quality assessments additional information on the site types (background, traffic, industrial) and surroundings (rural, suburban, urban) can be retrieved from AirBase and linked to the air quality quests sites.

Only measurement sites which according to the given information can be assumed to be still in operation were considered. Therefore, the number of AirBase sites to be taken into account reduced considerably compared to the number of 8.225 sites listed originally. Furthermore, there were a high number of double and triple entries (694) in the Airbase list that had to be eliminated. The same procedure had to be applied to the air quality quests since some double entries were found here, too. However, in most of these cases this was due to the function of the respective sites for monitoring of two different zones. Some examples (incomplete list) are given in Table 16. All sites listed in the sheets 3 and 4 of the air quality quests, comprising those used for the daughter directives 1 to 3, were combined to one list.

Table 16 Examples for double entries in questionnaire spreadsheets

Country	Stationcode	Localisation	Zone
ES	ES0009R	19061999	ES0708
ES	ES0009R	19016999	ES0812
ES	ES0012R	46263999	ES1010
ES	ES0012R	46263999	ES1401
UK	GB0642A	London Hillingdon	UK0001
UK	GB0642A	Tower Hamlets Roadside	UK0001

Using the measurement station codes the relation of the three used basic data compilations was investigated. This task was however complicated by the fact that in several cases the station codes were not usable as expected. For example, the codes listed in the column “EoI codes” in the air quality quests frequently were not assignable to the EoI codes used in AirBase. In many cases an assignment could be made using local codes given in both databases. The resulting relationship between the databases is shown in Figure 27. Unfortunately, for France none of the codes used for the sites provided a link between the two databases. The site numbers in AirBase and the air quality quests for France are 1282 and 814, respectively. Hence, it should be noted that the figure for the overlap between Airbase and the air quality quests is probably too low (and thus, the figure of 1715 sites being exclusively assigned to the air quality quests is too high).

However, as shown above in Figure 27 only ca. 40% of the air quality quests sites (for those countries data for which are available) could be assigned to stations listed in AirBase. Per country, the coverage varies considerably, as presented in Figure 28. Obviously, several countries (AT, DE, EE, ES, FI, IE, LU, UK) have reported data to Airbase for a high fraction (> 80%) of their air quality quests sites. On the other side of the range an insufficient (< 40%) coverage of the air quality quests sites by AirBase must be stated for CZ, SK, IT, and SW. In case of France there are more sites available in Airbase than needed to cover the air quality quests sites. Hence it might be possible that up to 100% of the French air quality quests sites are included in Airbase.

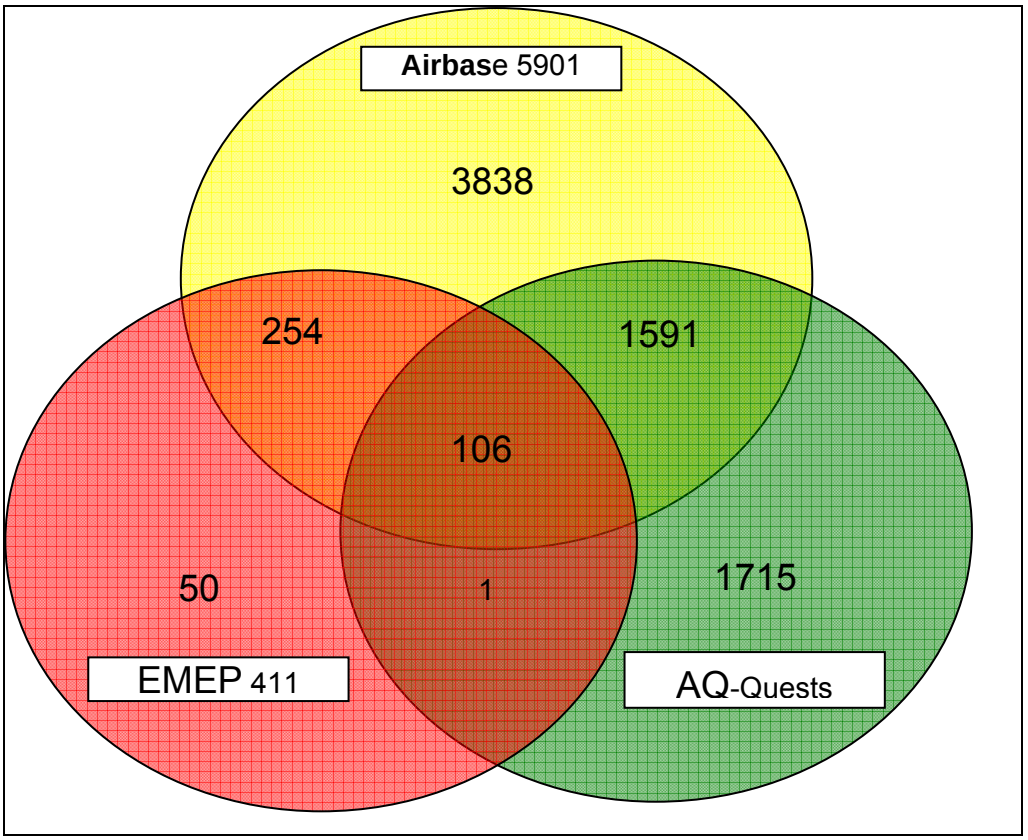


Figure 27 Numbers of air quality measurement sites included in the three databases AirBase, EMEP and air quality (AQ-)quests

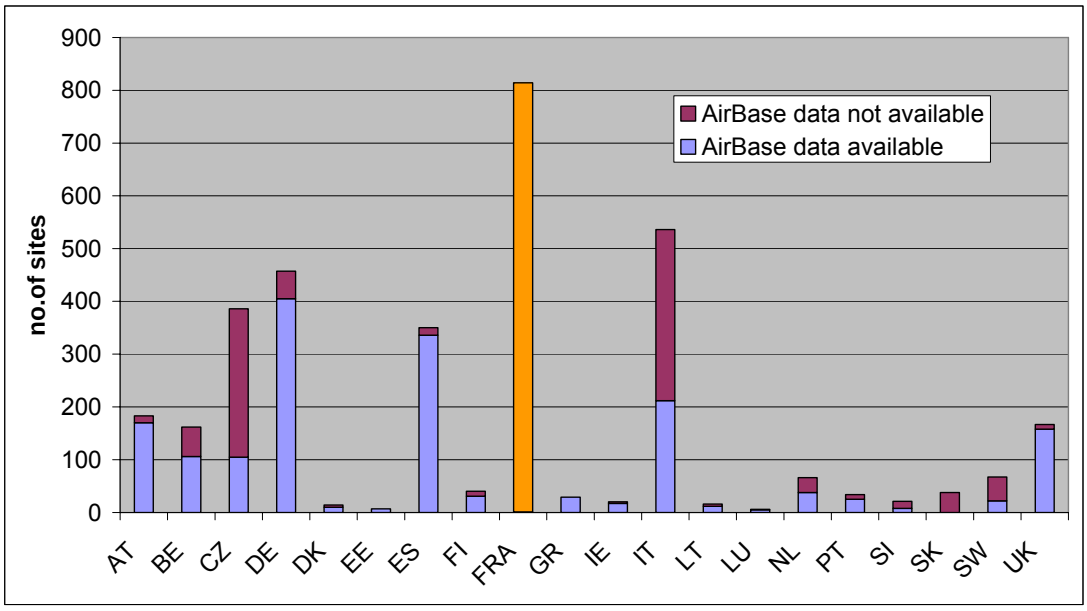


Figure 28 Number of air quality quests measurement sites by country included or not included in the AirBase database

The missing AirBase data for CZ, IT, the absence of any information for Hungary and Poland and the impossibility to relate the French air quality quests sites to the AirBase information

impose a considerable limitation for the analyses presented in the following. Therefore, pictures derived from any analysis of these data sets will be somehow incomplete and provisional [17].

Similar problems were also faced by the group preparing the report on the Member States reports under the air quality directives (vdHout 2005). However, for that report information on station types were obtained for overall 3,217 stations listed in the air quality questionnaires using additional information retrieved from the ETC and obtained by bilateral contacts to member state experts.

As a conclusion, Member States should be asked to check and complete their station data in Airbase. EoI station codes should be used in all measurement site databases to allow an unequivocal linkage of the various information stored.

6.11.2 Structure of the air quality assessment zones in the EU Member States

From the information provided in the air quality quests spreadsheets indications on differences regarding the approach taken in the Member States with respect to the definition of zones for the air quality assessments can be gathered. There are only minimal requirements in the Directives regarding the zone characteristics regarding area size, population and population density. Mainly the special zone type “agglomeration” has been defined as being a zone with more than 250.000 inhabitants or, in case of lower population, a zone with a population density justifying the assessment and management of air quality. Therefore, area size, population and population density of the air quality assessment zones may vary in wide ranges from country to country. The major reason for leaving this aspect to the countries has to be seen in the need for being able to manage air quality (e.g. by action plans) in case of exceedance of the limit values. To facilitate such management it was considered wise to define the assessment zones by taking into account the administrative units (such as municipalities or provinces).

Nevertheless, in principal one might expect that assessment zones would have some general characteristics:

- the minimum zone area would not be below a few km²,
- the population density in agglomeration zones would ideally exceed some threshold value which clearly separates agglomerations from non-agglomeration zones

However, an evaluation of the data reported in the air quality quests reveals surprising large variations and ranges, as shown in Table 17. A closer view reveals that the zone with minimum area belongs to Spain (city of Elx, zone code ES1018). The zone with the lowest number of inhabitants belongs to Belgium (BEF08S) and also has a very small size of 1.4 km². The lowest population density can be found in an Italian zone (IT1205) which is inhabited by only 333 persons.

At the other end of the range the largest zone area is constituted by the Swedish “Zone North”. Maximum population is reported for the Portuguese zone PT9000 covering the entire territory for this country. The highest population density is calculated for the smallest, Spanish zone in the city of Elx already mentioned. It is notable, that with execption of the Napoli zone in Italy all zones with population densities above 6,000 inh./km² are located in Spain.

[17] Similar problems were also faced by the group preparing the report on the MS reports under the air quality directives (vdHout 2005). With additional information retrieved from the ETC

Table 17 Gross statistics of zone characteristics as reported in the air quality quests (20 countries)[18]

	Area [km²]	Population [1000 inh]	Population density [inh./km²]
Minimum	0,8	250	0.05
Maximum	338,145	9,833,408	243,459
Mean	8,090	656,660	1,521
Median	842	277,904	218
Number of zones considered	572	647	567

The examples of the aggregated PT9000 zone which represents the whole territory of Portugal and the Spanish zone revealing an extraordinary high population density already shows that the zoning approaches chosen by the Member States may contain some peculiarities. Some particular features are presented in Table 18.

Accordingly, following zone types can be found:

- “normal” zones covering one or several adjacent administrative areas
- ”combined” zones covering several non-adjacent administrative areas which are assessed to have similar air pollution characteristics (e.g. all smaller cities surrounded by rural areas)
- “aggregated” zones covering large areas of the territory (or the whole territory) which are additionally covered by the previous zone types (thus taking reference to the same area twice or more times).

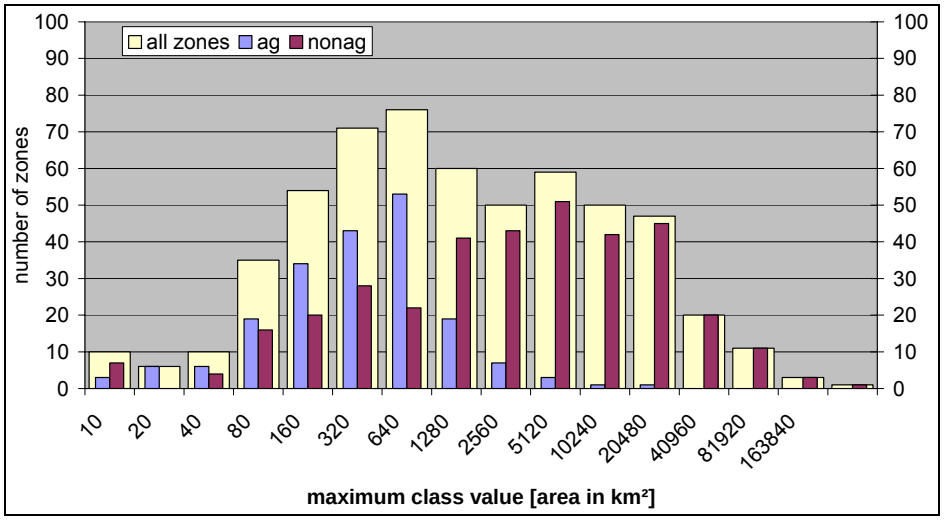
Table 18 Zone numbers and peculiarities in zoning approaches

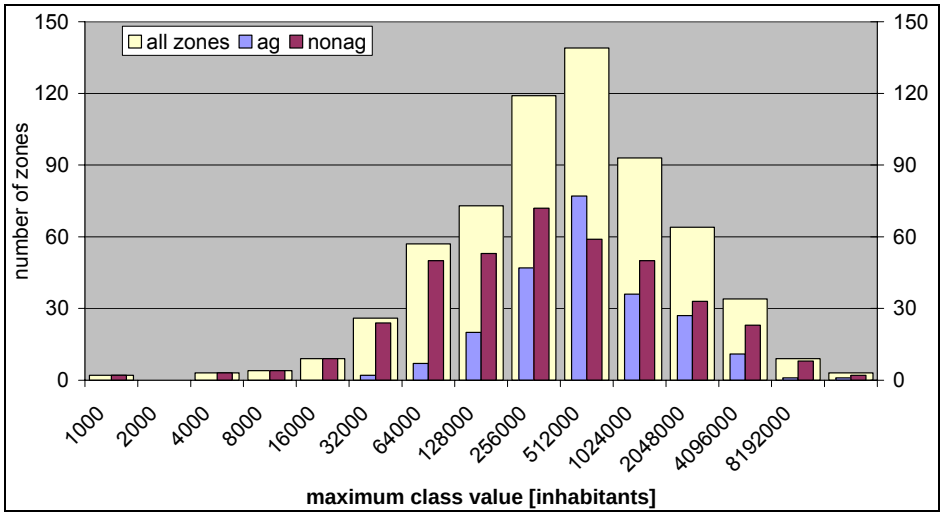
Country	**Number of zones**	**Special zoning approaches**
AT	19	special zone definitions for ozone
BE	17	one zone assigned to “cities > 50.000 inh.”
CZ	14	all zones described as “ag/nonag”
DE	125	different approaches with the German Länders; zone delineation and numbers vary by pollutant and is checked/changed annually. Some Länder combine spatially separated cities into one zone.
DK	10	delineation of country zone
EE	17	(only 16 zones acc. to vdHout 2005)
ES	143	one very small zone with pop. density > 200.000 inh/km (city of Elx)
FI	14 (+4)	four aggregated zones for ecosystem&vegetation protection
FR	88	overseas territory constitute separate zones
GR	4	
IE	4	
IT	139	
LT	4	(only 3 zones according to vdHout 2005)
LU	3	

[18] the different numbers of data considered in each column results from partially missing data; overall 710 zones are considered

Country	Number of zones	Special zoning approaches
NL	9	
PT	26	delineation of country zone
SI	9	Zone SI2 further divided in 3 sub-zones
SK	10	
SW	6	
UK	43	
Total	**708**	

Figure 29 shows the frequency distributions of area sizes, population and population densities for the 20 countries considered. Not surprising, the area distribution tends to be broad for non-agglomeration zones but is limited to small sizes in case of agglomeration zones. Also expectable, the population density distribution shows just the opposite features, with agglomerations showing a maximum at higher densities than non-agglomeration zones. However, there is a considerable overlap between these distributions in the range of 500 to 5000 inhabitants/km². Apparently there is no commonly applied value of population density to be used as the criterion to separate agglomeration and non-agglomeration zones.





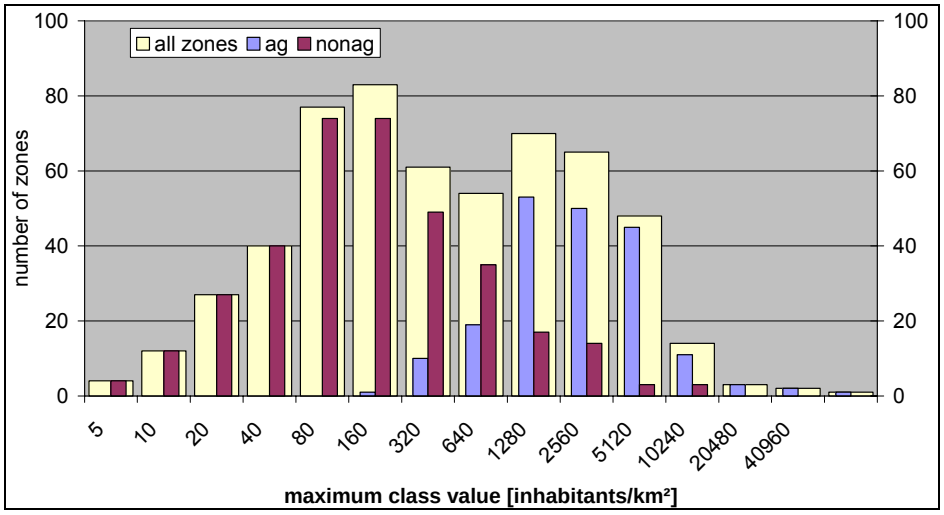


Figure 29 Frequency distributions of area sizes, population and population density for air quality assessment zones in 20 EU countries This is further illustrated by the analogue graphs made separately for 6 countries (Figure 30). While for AT and UK there is a clear separation of agglomeration and non-agglomeration zones into 2 groups with high and low population densities, resp., in all other countries shown overlaps between these groups occur.

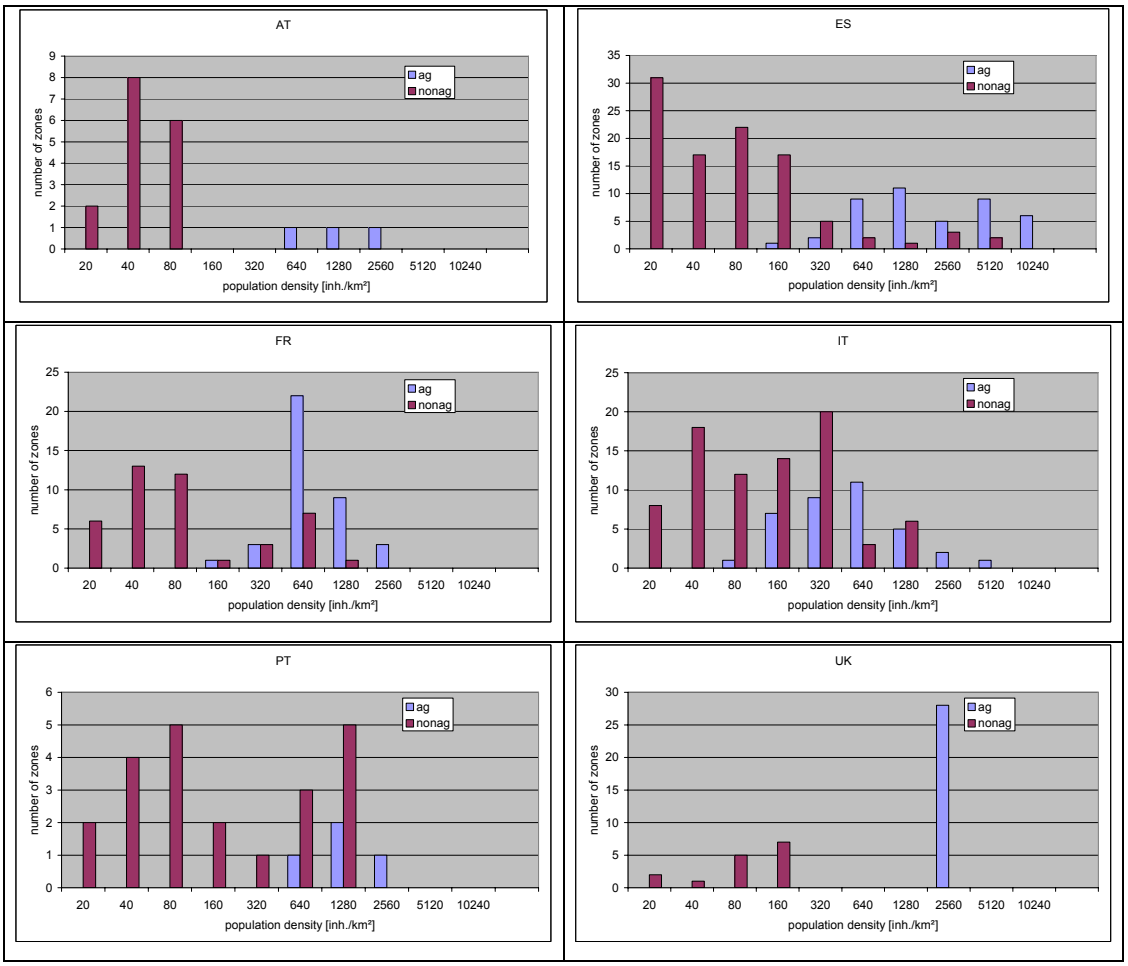


Figure 30 Frequency distributions of population density for air quality assessment zones in 6 selected countries

There might be different reasons why zones with comparatively low population densities were defined as agglomerations, and on the other hand, why zones with significantly higher densities

are not considered as agglomerations. However, these reasons cannot be assessed from the available information. Nevertheless, the apparent differences provide an indication for different zoning approaches that also might have an impact on the comparability of the air quality assessments between different countries.

For additional information on zoning characteristics it is referred to the very comprehensive overview (see previous section) presented in vdHout 2005.

6.12 Annex L: Types of sites and represented area and population

6.12.1 Types of air quality monitoring sites

In Figure 31 the numbers of measurement sites of different types used in the considered EU countries for air quality assessment according to the directives are presented. In most of the countries, background stations (which can further be broken down into area types urban, suburban or rural background, see Figure 32) are predominant. However, in e.g. Spain and Italy the number of “hot-spot” stations are higher than the number of background sites. This gives rise to the question of the fraction of population which is represented by the measurement results obtained. It is generally assumed that hot-spot situations only affect the air quality of quite small areas; although these might be highly populated (like around traffic hot spots in city centres) the air pollution values measured could be used as an indicator for exposure only for a limited number of inhabitants.

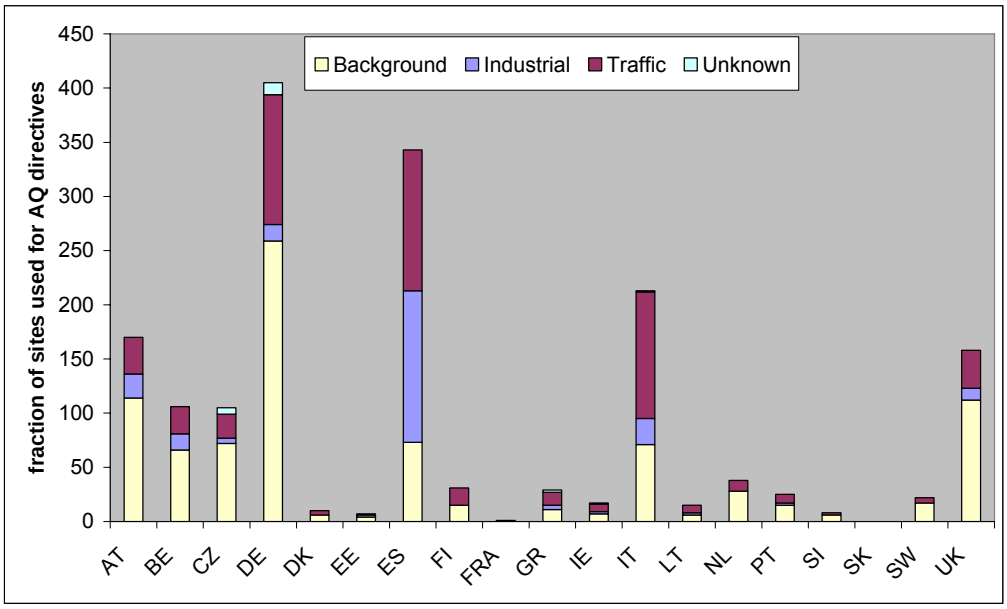


Figure 31 Measurement sites used for air quality assessment broken down by site functions and country

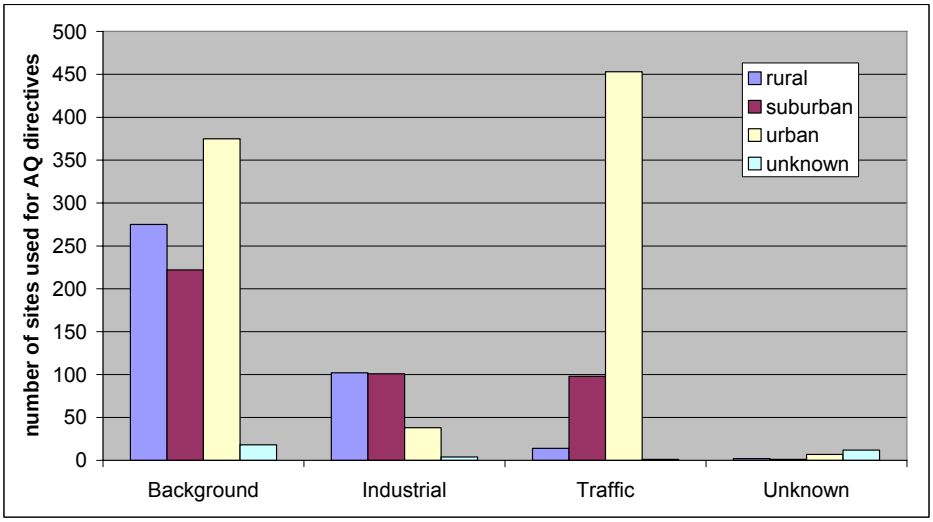


Figure 32 Distribution of site functions with regard to location characteristics

6.12.2 Representativeness of air quality monitoring sites in the EU

One of the major issues related to the use of ambient air quality data for the assessment of health effects is the question of representativeness of sites. This means, what area is actually represented by the measurements and what fraction of the population.

According to the air quality directives, with regard to the protection of human health, fixed measurements should be sited such as:

- - to provide data on the areas within zones and agglomerations where the highest concentrations occur to which the population is likely to be directly or indirectly exposed for a period which is significant in relation to the averaging period of the limit value(s);
- - to provide data on levels in other areas within the zones and agglomerations which are representative of the exposure of the general population.

The representativeness in terms of area and population could be further evaluated if - for each combination of site type and area type - the area for which the site is representative and the population density in this area were known. Such information is not available as yet as this would require an extensive analysis of intercorrelation between the measurement results of different sampling locations, (as exemplary shown below in 5.5.3), as well as the application of local dispersion models.

Nevertheless, with the information available some general insights may be gathered if typical values for area representativeness and population densities are estimated based on experience. The basic **representativeness model** chosen here is

a) to describe the area for which a site is representative in terms of the equivalent diameter of a circle around that site. This is an idealisation because e.g. prevalent wind directions would warp into clubbed areas in the real world.

Following values were used here for the modelling shown below:

- rural background:

  the spatial representativeness may range widely and have equivalent diameters between some 10 km and several 100 km depending on the land use characteristics. It may be assumed, since only measurement stations used for air quality assessment with relevance for human health are considered here, that those rural areas which must be taken into account are moderately populated and quite inhomogeneous with regard to land use. So the diameter of the circle around a rural background is likely to be around several tens of km and a value of 50 km was chosen.

- urban background

  experimental data obtained in the course of a PM_{10} measurement program in the highly populated area of Duisburg, Germany has shown two urban background sites with ca. 6 km distance to have significantly correlated PM concentrations (correlation factor > 0.98). Hence for the urban background a diameter of 5 km is assumed to be realistic.

- suburban background

  in view of the better dispersion conditions and more homogeneous source distribution (mainly traffic and domestic burning) compared to the urban background a representative diameter of 10 km is assumed.

- industrial sites:

  industrial emissions usually affect only a limited area in the adjacent surroundings (mainly by near ground emission sources). They also contribute to the regional and superregional

pollution levels but this cannot be taken into account here. So, regardless of the area type a representative diameter of 2.5 km is used.

- traffic sites:

in street canyons which most frequently occur in urban areas the concentration of pollutants can reach levels which are significantly higher than in the urban background. Such hot-spot situations are limited to quite small areas and therefore a representative diameter of 0.5 km is assumed.

b) to assess a factor with which the mean population density of a zone is multiplied to obtain estimates for the real densities in the vicinity of the site. Generally, one would expect a factor below 1 for rural areas and factors above 1 for suburban and urban areas. In a first approach these factors were determined by comparing the average population densities of zones which have only rural, only suburban and only urban measurement stations. The mean population densities for each type of zone (approx. 70, 1800 and 2,300 inh./km², respectively) were related to average population density of all zones which revealed to be ca. 1,600 inh./km². Consequently, factors of 0.04, 1.14 and 1.44 were obtained.

Using these predefined figures, the overall area represented by all measurement sites in a given zone was calculated and compared to the entire zone area. This shall be illustrated taking a 5.000 km² zone with 1 rural background, 3 urban background and 1 traffic site as an example (c.f. Table 19). The total area represented by these sites would be the sum of the areas covered by circles of the diameter 50 km*1.5 km**3 and 0.5 km*1 = ca. 2000 km². The fraction of zone area represented by the sites thus is approximately 40%.

In terms of population the average population density of the zone, here assumed to be 200 inh./km² is multiplied by the factors given above (0.04, 1.14 and 1.44, resp.) to obtain the site-specific population densities in the vicinity of the sites. Multiplying the area represented by each site with the site-specific population density reveals the population represented by the sites. The sum of the population represented by all sites together results in ca. 66.000 inhabitants, which are 7% of the entire zone population.

Table 19 Example for the evaluation of area and population representativeness using the assumed model values

zone area	km²	5000			
zone population	inhabitants	1000000			
mean pop.-dens	inh./km²	200			
		rural backg.	suburban backgr.	urban backgr.	traffic
diameter	km²	50	10	5	0,5
area	km²	1963,5	78,5	19,6	0,2
number of sites		1		3	1
represented area	km²	1963,5	0,0	58,9	0,2
total area	km²	2023			
represented area fraction	%	40%			
pop.-density factor		0,04	1,14	1,44	1,44
site-specific pop-dens.	inh./km²	8	228	288	288
population per site	inhabitants	15708	0	16965	57
population all sites	inhabitants	15708	0	50894	57
represented population	inhabitants	66658			
represented populaton fraction	%	7%			

Data from 348 zones could be used for the evaluation of represented area, and 311 zones for the represented population.

The area fractions obtained in the described way for all zones are displayed as a frequency distribution in Figure 33. Clearly, in most cases less than 10% of the zone area is represented by the sites used for air quality assessment, only in a few cases higher values are reached. Overall, only 0.5% of the entire zone area under consideration is represented by the measurement sites.

With regard to population it can be seen from the analogue diagram (Figure 33) that for a considerable number of zones significant fractions of the population are represented by the measurement site. Still, in most cases there are low values but there are also zones for which the fraction exceeds 100%. In these zones more measurement sites are operated than needed to represent the exposure of the entire population living there. Overall, 13% of the entire population living in the considered zones appear to be represented by the measurement sites.

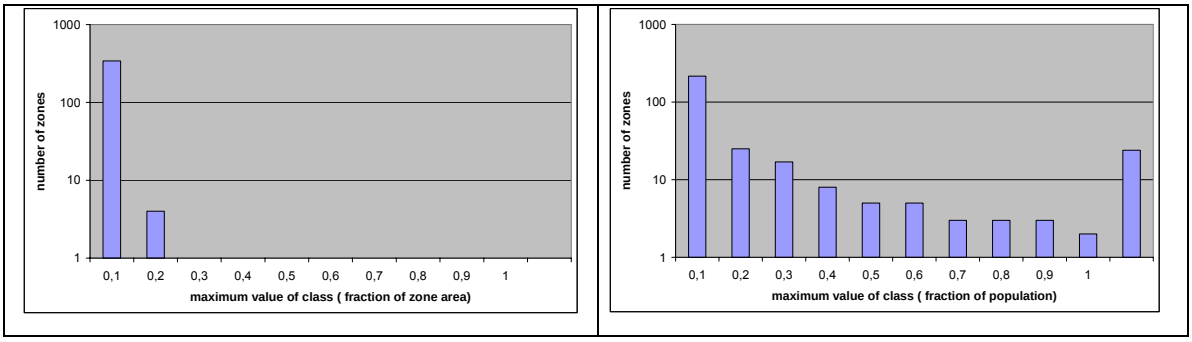


Figure 33 Frequency distribution of the fraction of a) zone area and b) population obtained by the representativeness model

a: 348 zones, overall area 192 million km²; b:311 zones, overall population 159 million inhabitants