National Environmental Research Institute
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Institutional Strengthening of
National Air Emission Inventories – CORINAIR

Air Quality Modelling and the National Emission Database

Research Notes from NERI No. 206

Danish Co-operation for Environment in Eastern Europe (DANCEE), Ministry of the Environment
and
The Government of Latvia, Ministry of Environmental Protection and Regional Development

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Steen Solvang Jensen

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Abstract: The project focuses on development of institutional strengthening to be able to carry out national air emission inventories based on the CORINAIR methodology. The present report describes the link between emission inventories and air quality modelling to ensure that the new national air emission inventory is able to take into account the data requirements of air quality models.

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Content

Acronyms

AQ	Air quality
CO	Carbon monoxide
CSDD	Road Traffic Safety Directorate
DANCEE	Danish Cooperation on Environment in Eastern Europe (DEPA programme)
DEPA	Danish Environmental Protection Agency
LEA	Latvian Environmental Agency
EMEP	European Monitoring and Evaluation Programme
EPA	Environmental Protection Agency
EU	European Union
ESI	Environmental State Inspectorate
LHMA	Latvian Hydrometeorological Agency
MEPRD	The Latvian Ministry of Environmental Protection and Regional Development
NERI	National Environmental Research Institute, Denmark
NO_2	Nitrogen dioxide
NOx	The sum of nitrogen monoxide nitrogen dioxide
O_3	Ozone
OML	Danish AQ regulatory modern Gaussian model for point sources and also area and line sources recommended by the Danish EPA. Developed by NERI.
OSPM	Operational Street Pollution Model. Street canyon model recommended by the Danish EPA for AQ assessment in Danish cities
PM10	Particles less than 10 µm in diameter
RCC	Riga City Council
REB	Regional Environmental Boards
RREB	(Greater) Riga Regional Environmental Board
SO_2	Sulphur dioxide
VOCs	Volatile Organic Compounds

Summary

The project focuses on development of institutional strengthening to be able to carry out national air emission inventories in Latvia based on the European CORINAIR methodology. The present report describes the link between emission inventories and air quality modelling to ensure that the new national air emission inventory is able to take into account the data requirements of air quality models.

The first part of the report illustrates how emission data can be used in air quality assessment on different geographic scales (regional, urban, street and individual industrial sources) and pinpoints what supplementary data is required to be able to utilise emission data for air quality modelling. An assessment has been carried out of the parameters required for air quality modelling and compared to existing emission data to be able to specify supplementary parameters. These supplementary parameters should be collected as part of the national emission inventory with special attention to point sources. A procedure for collection of supplementary data has briefly been discussed.

To improve future air quality assessment based on modelling it is important that the Regional Environmental Boards/Latvian Environmental Agency (REB/LEA) builds up a database that contains necessary parameters for stationary and other sources needed for AQ modelling. In the process of building a national emission inventories based on CORINAIR, REB/LEA should supplement their existing database with necessary information needed for air quality modelling and make such data are available for air quality modelling purposes.

Resumé

Nærværende projekt handler om institutionsudvikling i forbindelse med opbygning af en national emissionsopgørelse for Letland baseret på den europæiske CORINAIR metode. Rapporten beskriver sammenhængen mellem emissionsopgørelser og luftkvalitetsmodellering for at sikre, at den nye nationale emissionsopgørelse tager hensyn til de datakrav, som luftkvalitetsmodeller stiller.

Første del af rapporten illustrerer, hvordan emissionsdata kan anvendes til luftkvalitetsvurdering på forskellige geografiske skalaer (regionalt i Europa, byområder, enkelte gader, samt industrielle kilder). Endvidere beskrives de supplerende data, som er nødvendige for at kunne anvende emissionsopgørelser til luftkvalitetsmodellering, og det er vurderet hvilke supplerende parametre, det er nødvendigt at indsamle i forhold til eksisterende data. Disse supplerende parametre bør indsamles som en del af den nationale emissionsopgørelse med særlig vægt på de industrielle kilder. En overordnet procedure for, hvordan disse data kunne indsamles er kort diskuteret.

For at kunne forbedre den fremtidige luftkvalitetsvurdering i Letland baseret på luftkvalitetsmodeller er det vigtigt at de regionale og nationale miljømyndigheder i Letland (Regional Environmental Boards/ Latvian Environmental Agency) opbygger emissionsopgørelser, som indeholder nødvendige supplerende data for industrikilder og andre kilder, og stiller disse til rådighed for luftkvalitetsmodellering.

1 Introduction

Previous project on AQ assessment and modelling

Danish Co-operation for Environment in Eastern Europe (DANCEE), has carried out a previous project in co-operation with the Government of Latvia with the aim to assist Lavia in implementation of the EU Ambient Air Quality Directives. The project objectives were to develop institutional capacity at Latvian Hydrometeorological Agency (LHMA), Riga City Council (RRC) and REB (Regional Environmental Boards) for ambient air quality assessment and management, monitoring of AQ in accordance with EU requirements and institutional capacity to provide information on AQ to the general public, decision-makers and the EU.

Present project on emission inventory

The present project focuses on development of institutional strengthening to be able to carry out national air emission inventories based on the CORINAIR methodology. To create a linkage between the previous and present project an activity was defined to link emission inventories and AQ modelling by ensuring that the new national air emission inventory would take into account the data requirements of AQ models. The activity is described as 'Description of data for modelling air quality for point sources to be included in national emission database'. The project is headed by the Danish Toxicology Centre in association withthe National Environmental Research Institute.

Supplements to emission inventory to meet AQ modelling requirements

A national emission inventory provides important information about emissions from various sources and when repeated it provides information about trends in emissions. However, air quality modelling is able to link emissions to concentrations in the environment that cause health and environmental effects. The advantages of AQ modelling is that it is a powerful tool for AQ assessment and management since it is possible to map the spatial and temporal variation of concentrations at various geographic scales. Furthermore, it is possible to evaluate the contribution from different emission sources to concentration levels, and to do backcast and forecast and 'what if' scenarios. Air quality modelling is also stressed as an important tool for AQ assessment in the EU ambient framework and daughter directives.

In the process of building up a new national emission database in Latvia it is important that the database is designed to support air quality modelling. This is the also the trend in European countries e.g. in Denmark.

The present emission database for stationary sources at Regional Environmental Boards/ Latvian Environmental Agency (REB/LEA) has limitations concerning the parameters needed for air quality modelling. Due to the limitation of the emission database provided by REB/LEA it is not possible to partition total emissions from a single source to the different stacks of the source. Furthermore, data is not available on gas temperature and gas flow and limited data is available on time variation of emissions. Additional, information to adjust for effect of buildings on concentration levels is not available.

To improve future air quality assessment based on modelling it is important that REB/LEA builds up a database that contains necessary parameters for stationary and other sources needed for AQ modelling. In the process of building a national emission inventories based on CORINAIR, REB/LEA should supplement their existing database with necessary information needed for AQ modelling and make such data available for air quality modelling purposes.

Content of activity

The present report summarises the following activities. The first part illustrates how emission data can be used in AQ assessment on different geographic scales (regional, urban, street and individual industrial sources) and pinpoints what supplementary data is required to be able to utilise emission data for AQ modelling. An assessment has been carried out of the parameters required for air quality modelling and compared to existing emission data to be able to specify supplementary parameters. These supplementary parameters are needed to be collected as part of the national emission inventory with special attention to point sources. A procedure for collection of supplementary data has briefly been discussed.

The activity had a very limited time budget that included a presentation on emissions in AQ modelling during the training course 20-23 October 2003 in Denmark for Latvian specialists and writing up the present short report.

2 Application of Emission Data in AQ Modelling

AQ models provide linkages between emissions and concentrations, and concentrations are more directly related to the exposure of humans and the environment and hence more directly linked to the harmful effects of air pollution. The magnitude of a health or environmental problem may not be evaluated based on emissions alone since there is not a linear relationship between emissions and concentrations. An emission source may be dominant in an emission inventory but its contribution to concentrations may be less significant due to the location of the source and how the emission is dispersed and transformed, and how humans and nature are exposed.

In the following, examples are provided on how emission data can be applied in air quality modelling for use in air quality assessment and management. Examples are given on different geographic scales: regional, urban and local, since the physical and chemical processes that governs the relation between emissions and concentrations are very different at different scales. Furthermore, it is discussed how national emission inventories can be applied in AQ modelling and what supplementary data is required. Examples are drawn from AQ models developed at the National Environmental Research Institute in Denmark and to the extent possible data from Latvia from the project on assistance to Lavia in implementation of the EU Ambient Air Quality Directives.

2.1 Regional scale

National emission inventories and international conventions

National emission inventories provide important information about emissions from various sources and trends in emissions. National emission inventories are also important tools to assess if national emission ceilings are met as part of international agreed targets.

The national emission inventories in Europe are collected under the European Monitoring and Evaluation Programme (EMEP). In Europe national emission inventories are based on the CORINAIR methodology. National emission ceilings are agreed under the Convention on Long-range Transboundary Air Pollution. The convention focuses on pollutants related to formation of ground-level ozone, acidification, eutrofication and persistent organic pollutants. Regional AQ models are important tools used to model regional concentration and deposition to assess health and environmental effects, and to model cost-effective emission reduction scenarios.

Regional models

The Danish Eulerian Operational Model (DEOM) is an example of model that is able to predict concentration levels at a regional scale since it covers all of Europe. The model is developed at the National environmental Research Institute in Denmark. EMEP operates similar models. Regional background levels correspond to conditions outside cities in rural settings not directly affected by local sources. The

DEOM model is an Eulerian dynamical long-range transport/chemistry model using meteorological data from Eta. It describes physical and chemical processes like transport, dispersion, chemistry (35 species) and wet/dry deposition. The DEOM model will soon be replaced by a new and improved model named the Danish Eulerian Hemisperic Model (DEHM-REGINA) model that covers the entire Northern hemisphere and has improved descriptions of the physical and chemical processes. An example of model output from DEOM is shown in Figure 2.1.

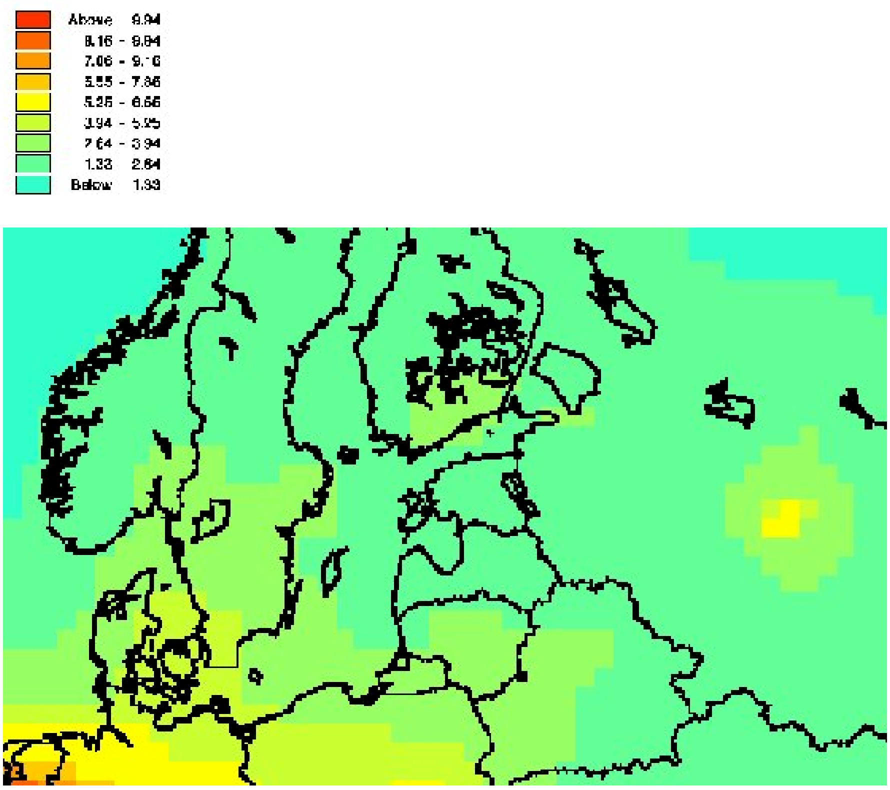

Figure 2.1 An example of the spatial variation of NO_2 concentration (ppb) in 1999 based on the DEOM model with a grid resolution of 50x50 km^2. Here shown with Latvia and surrounding countries.

Emissions on grids

The model is based on emission data from European Monitoring and Evaluation Programme (EMEP) that is based on national emission inventories from the different European countries.

National emission inventories have a geographic resolution at country level and no temporal resolution. However, models like the DEOM model require emission data on a finer resolution e.g. 50x50 km^2 for Europe that is equivalent to the EMEP grid in Europe.

The geographic distribution of national emission into a grid of 50x50 km^2 has been carried out using different weight parameters e.g. population data. EMEP has carried out the geographical distribution of emission on the EMEP grid. However, it is a recent requirement that each country also has to report national emission on the 50x50 km^2 EMEP grid covering their country every 5th year starting from 1990. In most countries the national emission inventory has a finer geographic resolution than the whole country e.g. counties. Such information can be used to transform data into the required grid resolution. Figure 2.2 illustrates the principles of how emission data on a certain spatial resolution can be transformed into emissions in a grid based on different weight themes. Such operations are most effectively carried out using Geographic Information systems (GIS).

Recommendation

It is recommended that LEA applies GIS methods based on weight themes for distribution of national emissions to the EMEP grid of 50x50 km^2 covering Latvia.

The Danish National Survey and Cadastre has recently defined a National Square Grid covering all Denmark. It has a fixed starting point and has several different grid resolutions e.g. 100*100 m^2, 1*1 km^2, 10*10 km^2 etc. Each grid cell has a unique key that identifies the grid cell depending on the grid resolution. This means that data that has been assigned to the National Square Grid can be exchanged in tabular form. Therefore, it is independent of specific GIS software but can still easily be visualised in any GIS software. It is also recommended that Latvia defines a similar standard National Square Grid to ease data exchange. It will be extremely useful to have emission data available on such grids for AQ modelling and the long-term goal should be to have emission data not only at 50*50 km^2 required by EMEP, but also at a finer grid resolution. In section '2.2 Urban scale' it is illustrated how emission data on a 1*1 km^2 grid can be used to model urban background concentrations.

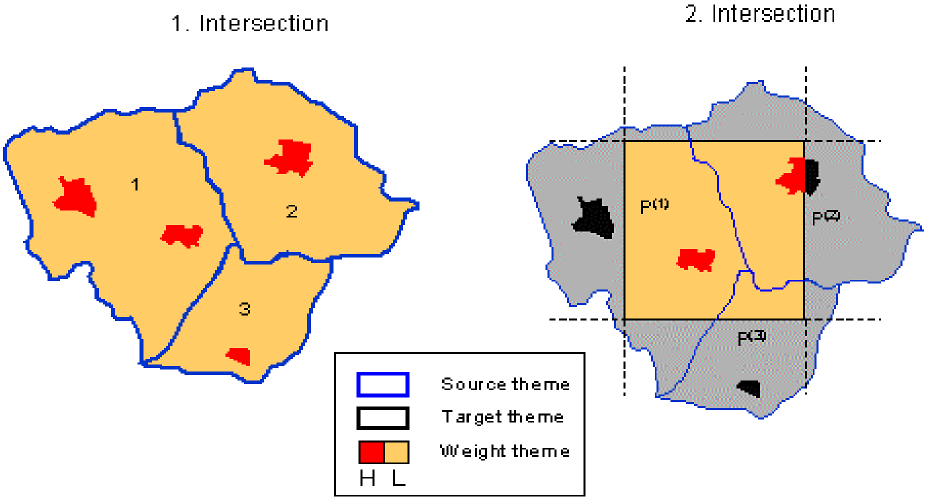

Figure 2.2 Illustration of how emission data on a certain spatial resolution can be transformed into emissions in a grid based on different weight themes using Geographic Information systems (GIS).

Temporal variation

The regional model also requires a description of the temporal variation of emissions, that is, the seasonal and diurnal variation. EMEP requests this information on a voluntary basis and it is not a formal requirement that the countries have to provide this information. However, it may be a requirement in the future to provide information on the temporal variation of emissions, similar to the recent requirement to provide emission on the EMEP grid.

Recommendation

It is recommended that LEA establish information about the temporal variation in emissions although it is not yet a formal requirement. It is not necessary to collect such information for every stack but just for different typical main categories that are substantially different in temporal variation e.g. industrial sources, power plants, heating plants, residential heating, traffic etc. Such information is useful as input at the regional scale by also for local scale AQ modelling as demonstrated in section 2.2 Urban scale.

Regional modelling in Latvia

At present, no institution in Latvia is carrying out regional modelling and it is not likely in the near future that this capacity will be built up in Latvia. Regional modelling is carried out under the European Monitoring and Evaluation Programme (EMEP) with similar models as the presented Danish models. Latvia is able to obtain regional modelling results covering Latvia from EMEP.

2.2 Urban scale

Urban AQ assessment and management

AQ modelling is a powerful tool for AQ assessment and management on the urban scale since it is possible to map the spatial and temporal variation of concentrations within a city. Furthermore, it is possible to evaluate the contribution from different emission sources to concentration levels, and to do backcast and forecast and 'what if' scenarios. Air quality modelling is also stressed as an important tool for AQ assessment in the EU ambient air framework and daughter directives.

EU directives on assessment and management

For the first time in European air quality directives, the EU Framework Directive and the first Daughter Directive introduce the use of modelling in combination with measurements for assessment and management of air quality. The Framework Directive refers in its preamble to "the use of other techniques of estimation of ambient air quality besides direct measurement", defines that assessment "shall mean any method used to measure, calculate, predict or estimate the level of a pollutant…" It further states that modelling techniques may be used. The first Daughter Directive expands this by introducing the use of supplementary assessment methods (AQ models, emission inventories, indicative measurements). It does not recommend specific models to be used, but it indicates data quality objectives for models in terms of accuracy. Together with monitoring data AQ modelling has an important place in the preliminary assessment where a EU member state has to divide the country into zones and assess the air quality in these zones in relation to EU air quality limit and threshold assessment values. If Member States exceed a limit values (plus margin of tolerance) they are required to prepare action plans to document that limit values can be met by the attainment dates. AQ models have an important place in air quality management. Through models, the contributions to exceedances of limit values from various sources and source categories can be established and 'What if' scenarios can be used to evaluate cost effective abatement strategies.

Demonstration of AQ modelling in Riga

- The application of dispersion models as a supplementary tool for preliminary assessment was demonstrated in the pilot area of Riga. The following outcomes were demonstrated:
- Mapping of the spatial distribution of pollutants in the pilot areas on urban background and street scale.
- Assessment of the modelled concentrations against the EU limit values, upper and lower assessment threshold values and margin of tolerance
- Introduction of the use of models for AQ action plans through examples of scenarios.
- Indicative validation of model estimates against measurements.

In the following the applied AQ models will be described in brief with special focus on emission requirements.

Overall approach

The overall approach is to model concentrations in the urban background describing the general pollution over the city, and concentrations at street level. This coupled approach is necessary since street pollution models require inputs about the urban background. The urban background model also requires input about the regional background. The OML model has been used to model urban background concentrations and the OSPM model has been applied to model street concentrations in selected street canyons. These models have been delivered to key institutions in Latvia.

OML

The Danish OML model is a modern Gaussian plume model based on boundary layer scaling instead of relying on Pasquill stability classification. It belongs to the same class of models as e.g. UK-ADMS and US- AERMOD.

The OML model is intended for distances up to about 20 km from the source. Typically, the OML model is applied for regulatory purposes in Denmark. In this case, the source is typically one or more industrial stacks. In particular, it is the recommended model to be used for environmental impact assessments when new industrial sources are planned in Denmark and environmental permits are issued. The OML model has also been used for AQ assessment on an urban scale including point, area and line sources. The model can be used for both high and low sources. The model takes into account simple photo-chemistry and the interaction with the regional background air. The model requires information on emission and meteorology on an hourly basis and input data about the receptors and the source, building and terrain topography, and regional background concentrations. Meteorological parameters are provided by the OML preprocessor, which is a separate software package. It computes a time-series of concentrations at user-specified receptor points, from which statistics are extracted and presented to the user, also graphically. The model takes into account building effects. It is not suitable for complex terrain conditions.

OSPM

The OSPM model is a street canyon model. A street canyon is a street with continuous buildings several storeys tall at both sides of the street. However, the model can be used for streets with irregular buildings or even buildings on only one side of the street but it is best suited for regular street canyon configurations. The Danish EPA recommends the model for AQ assessment in streets.

The model is a combined Gaussian plume model (direct contribution from traffic) and a box model (re-circulation contribution). The model takes into account the interaction with the urban background air. The model also takes into account the re-circulation of air in the street canyon and also simple photo-chemistry between NO, NO_2 and O_3 to predict NO_2 concentrations. Hourly concentrations of all calculated pollutants or/and statistical parameters as average values and percentiles. Modelled concentrations can be related to EU limits. Substances included are: NO_2, (NO_x), O_3, CO and benzene and PM10.

The COPERT methodology has been implemented as an emission module integrated into the OSPM model. The model should not be used for crossings or for locations far away from the traffic lanes.

Required inputs

The input requirements of the OML and OSPM models are summaries in table 2.1.

Table 2.1 Input requirements of the OML and OSPM models

Type of input	OML model	OSPM model
Source	• Industrial point sources • Location of source • Stack height, diameter, type etc. • Area sources (heating, traffic)	Line source in streets No. of vehicles in different vehicle categories in street canyons
Emission	• Emission strength • Temperature • Gas rate flow • Time variation	COPERT III emission factors based on car fleet characteristics (No. of vehicles in emission classes and annual km travelled). Diurnal variations in traffic (number, travel speed, cold starts)
Receptor	Circular or grid net Receptor height	Receptor located close to building facade at both sides of the street Receptor height
Topography	• Terrain height • Largest terrain inclination • Effective building height • Directional dependent building height • Aerodynamic roughness length • Release height and building height for area sources	Street configuration data - general building height - building height in wind sectors - street orientation and width - distance to street intersections
Meteorology	• Pre-processed hourly meteorological data from synoptic met. station and twice-daily vertical temperature profiles from radio-sonde station	Hourly time-series of wind direction, wind speed, temperature, humidity and global radiation
Boundary conditions	• Hourly time-series of regional background concentrations	Hourly time-series of urban background concentrations
Chemical transformation	• Simple photo-chemistry between NO, NO_2 and O_3 to estimate NO_2	Simple photo-chemistry between NO, NO_2 and O_3 to estimate NO_2
Output	• Statistics based on hourly concentrations for receptor points	Statistics based on hourly concentrations for both sides of the street

2.2.1 Emission inventory for the OML model for urban background modelling

Point and area source data have been collected by the LHMA and all data have been stored in EnviMan system. Data originates from REB and RCC.

Point sources

444 point sources are included for Riga. The locations of the point sources are shown in Figure 2.3.

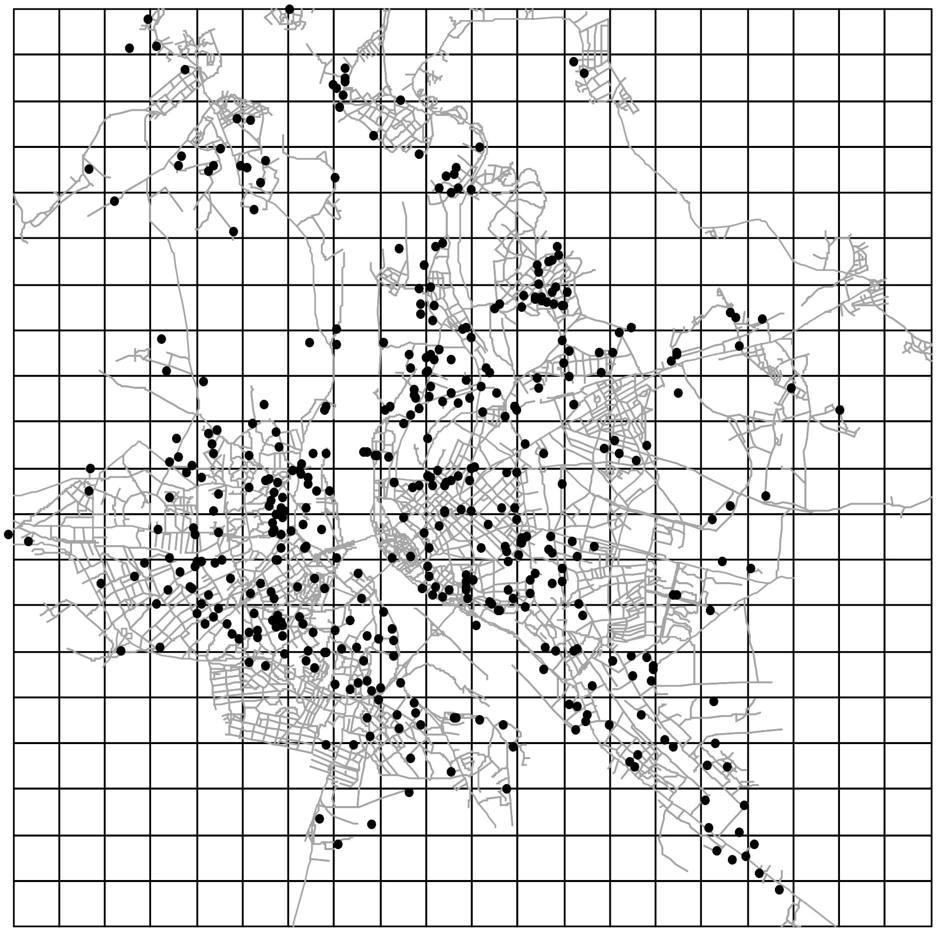

Figure 2.3 Location of point sources in Riga

The emission data for the point sources originate from the REB/LEA emission database. Latvia is fortunate to have a quite detailed emission database due to the fact that there is a tax on emissions. If the national emission database was only to include point sources that Latvia had to report under the CORINAIR reporting system, detailed information had to be provided for only a few point sources. The emission estimation is based on fuel consumption for the various processes and emission factors based on a mix between a Russian method and the CORINAIR system. However, from an AQ modelling point of view there were limitations of the emission database provided by REB/LEA since it is not possible to distribute total emissions from a single source to the different stacks of the source. Furthermore, data is not available on gas temperature and gas flow. This data was estimated based on best judgement.

Recommendation

For industrial point sources it is essential that an emission database include the following parameters and the exiting emission database should be supplemented with parameters not registered at the moment:

- Location of source (co-ordinates)
- Stack height and diameter
- Emission strength (related to each stack)
- Gas temperature (related to each stack)
- Gas rate flow (related to each stack)
- Time variation (representative for its type).

It will not be very demanding to collect this information since it should be available and can easily be collected as part of existing collection procedures.

The existing database includes rather small point sources and there is no need from an AQ modelling point of view to include even smaller point sources.

Heating as area sources

If a point source becomes very small like a chimney in a one family house it is not necessary or effective to treat the source as a point source in AQ modelling. In these cases the single source is pooled together with similar sources and can be considered an area source, that is, the emission is considered to be evenly distributed over an area. Residential heating and traffic are considered area sources and treated as such in AQ modelling aiming at estimating urban background concentrations.

Riga is dominated by district heating. District heating is provided by power plans and large boilers. These stacks are treated as point sources. However, there is a development towards more individual boilers powered by natural gas in individual houses and building complexes. All these small point sources as usually treated as area sources in modelling based on fuel consumption and emission factors. From an air quality point of view, the development towards individual systems will cause higher concentrations than a centralised system because the pollution is emitted from a lower height (individual buildings) compared to tall stacks that provide for more dilution.

Recommendation

So far no information has been collected about emissions from individual heating. In a national emission database individual boilers should not be registered as single sources. However, emission data on residential heating should be available on a finer grid resolution of e.g. 1*1 km^2 based on weight themes like population, area of residences or alike.

Traffic as an area source

Traffic data has been obtained for about 100 of the main roads in Riga. These data are stored in an emission and AQ management system (EnviMan). Emission factors from the COPERT emission module in the OSPM model has been applied to obtain vehicle emissions on a 1*1 km^2 grid. An estimate of the emission from the rest of the road network has been carried out using a bottom up approach. A digital road network is available with three road classes. It is assumed that all class one roads are covered by the main roads. Class two roads have been assigned traffic levels of 1000 and class three roads of 300. Emission factors from the COPERT emission module in the OSPM model has been applied. ArcView GIS was used to summaries the emission in each grid cell of 1*1 km^2 grid.

The spatial distribution of NOx emissions is shown in Figure 2.4. The highest emissions take place in the central part of Riga, densely populated areas and along the main roads. The spatial distribution of the other traffic related pollutants will show a similar pattern.

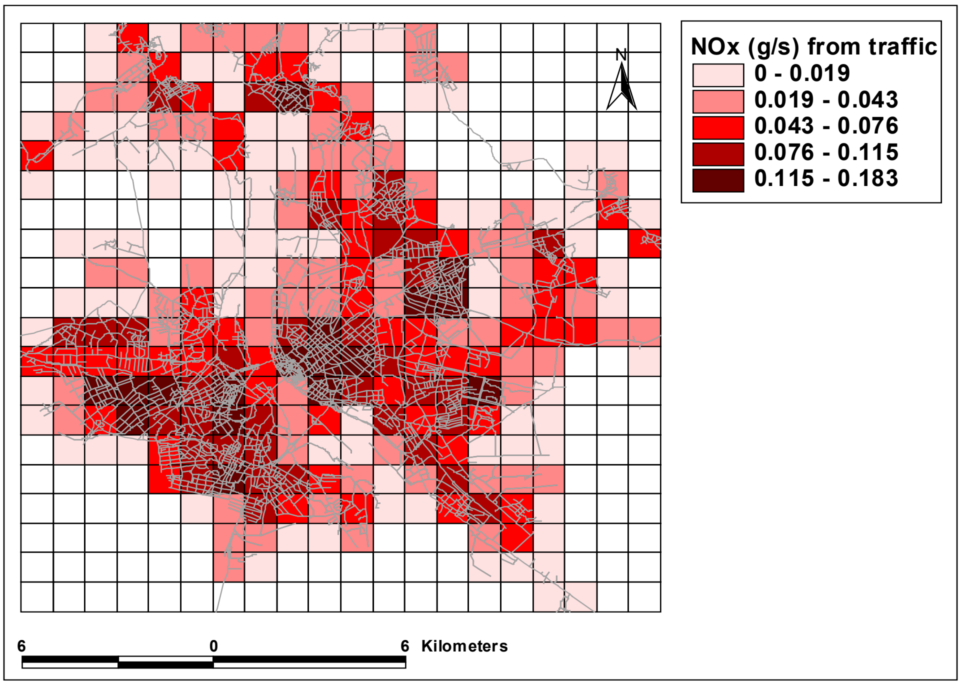

Figure 2.4 Spatial distribution of NOx emissions (g/s) in 2000 from traffic in Riga prepared with ArcView GIS

Car fleet characteristics for emission estimation

Emissions in the OSPM emission module are calculated from the traffic volume and the vehicle specific emission factors based on the COPERT III methodology. To be able to estimate emission factors at street level using the COPERT emission module it is necessary to obtain data on the national car fleet. The number of cars in different emission regulation categories (emission classes) and engine sizes have been obtained for the vehicle categories: passenger cars (gasoline, diesel, LPG), vans (gasoline, diesel), trucks (gasoline, diesel), and buses (gasoline, diesel). A data set has been established for the Latvian car fleet to reflect Riga. Since the national emission inventory also is based on the COPERT methodology it is an example of how national data can be utilised at the local scale.

CSDD provided information about car fleet characteristics. No information was available on engine size for passenger cars. The distribution of engine size was based on information about the brand of cars e.g. VW Polo was assumed to have an engine size below 1.4. Some uncertainties were introduced in this way and CSDD should maintain a database with the data needed for the COPERT methodology that is also the basis for the national emission inventory for vehicles.

Danish experience shows that COPERT underestimates real world emissions for NOx and CO in city streets at a travel speed of about 50 km/t. However, COPERT emission factors may more representative for the average conditions applied in national emission inventories. To be able to evaluate emissions a point monitor in a street location is necessary. Such a station has recently been established in Riga.

Fuel characteristics

The average content of benzene, sulphur and lead in gasoline and diesel has been obtained from LEA based on regulation. However, no information is available on the actual content since no or little control is carried out by the authorities. The content of benzene may be up to 5% but the actual content may be lower. Calculations have been carried out assuming 1% and 5%. It is important that such information is collected both from a national and a local point of view.

Temporal variation

The temporal variation of traffic was based on an analysis of the weekly and diurnal variation of traffic at about 20 different streets in Riga. The street of Valmieras was chosen as a representative street for all streets in Riga. Data from this street was used to generate the weekly variation and the diurnal variations for Monday to Thursday, Friday, Saturday and Sunday. The seasonal variation was been assumed to be constant as no data is readily available.

To estimate the temporal variation in relation to a national emission database for vehicle emissions on the EMEP grid of 50*50 km^2 a typical temporal variation in cities and on main roads could be weighted to give the temporal variation of a coarse grid like 50*50 km^2.

2.2.2 Examples of spatial distribution of concentrations

The OML model has been used to model urban background concentrations in Riga with emission data representative for 2000 for NO_2 and SO_2 and meteorological data from 1994. Two examples of the spatial distribution is given: one for NO_2 that is dominated by traffic sources and one for SO_2 that is dominated by industrial sources.

Annual levels of NO_2

The spatial distribution of annual average of NO_2 concentrations is shown in Figure 2.5.

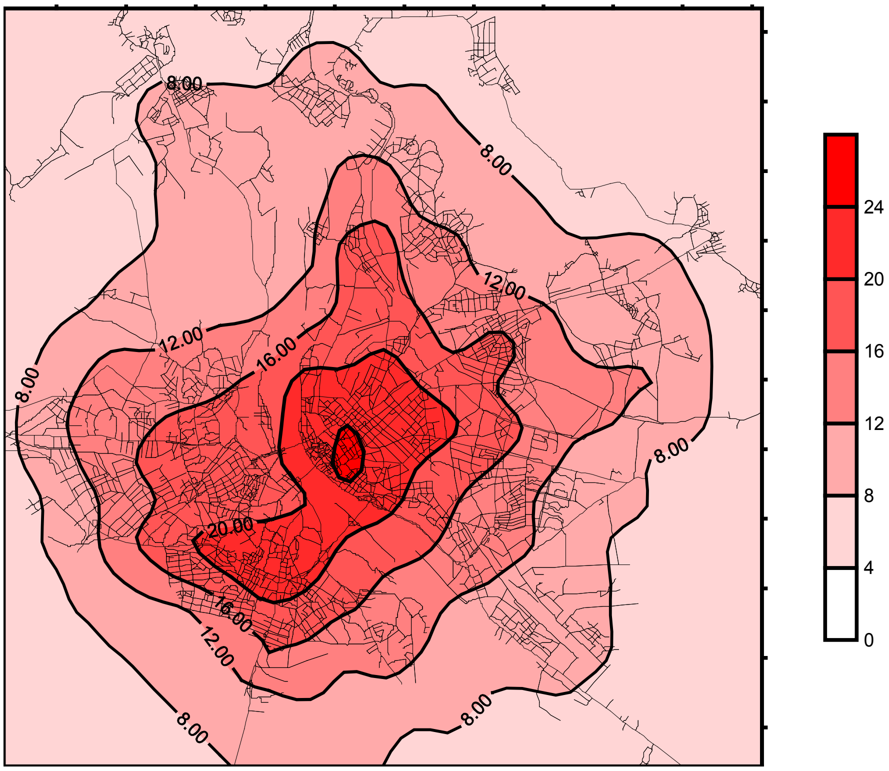

Figure 2.5 The spatial distribution of annual average of NO_2 concentrations in 2000 in µg/m³.

Highest 1h SO_2

Figure 2.6 shows the spatial distribution of the highest 1h SO_2 concentrations.

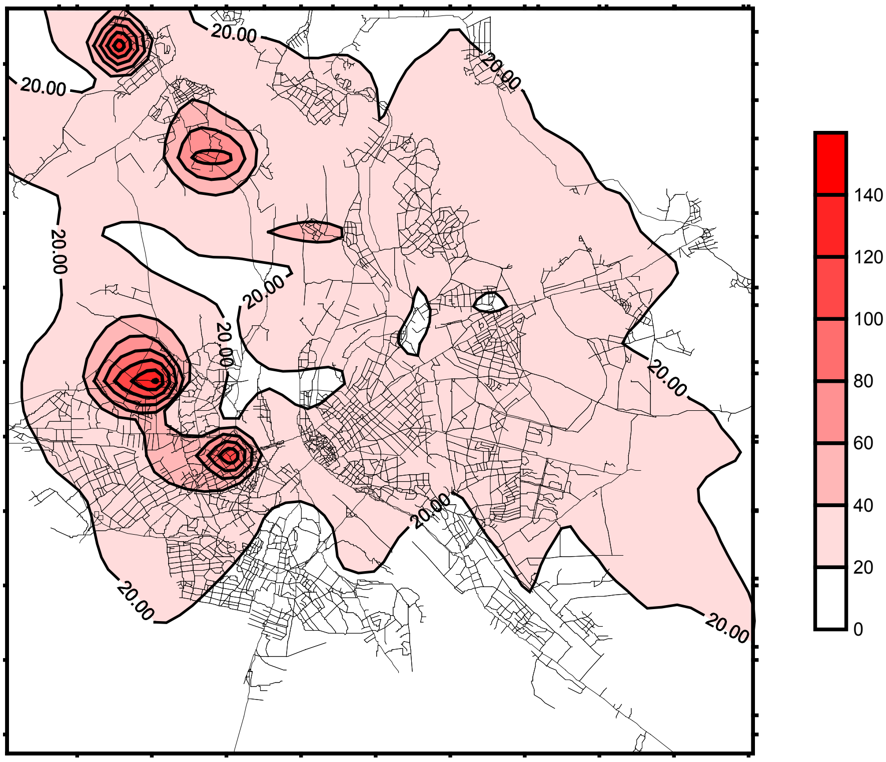

Figure 2.6 The spatial distribution of the highest SO_2 concentrations (1h) in 2000 in µg/m³.

2.2.3 Source contribution to concentrations in Riga

The total emissions from the industry and the traffic are summarised in Table 2.2. NOx emission from the industry and traffic is at the same level. CO emissions from traffic is about 75% of total CO emission, and a similar distribution is expected for benzene although very limited data is available on benzene from stationary sources. SO_2 emission is entirely dominated by the industry since traffic only contributes less than 2%.

Table 2.2 Distribution of total emissions on the different industrial categories in 2000

Industry	Nox (tonnes)	CO (tonnes)	Benzene (tonnes)	SO_2 (tonnes)
Industry	1435	4056	n.a.	1166
Traffic	1683	10947	365	18
Total	3118	15003	365	1184

Separate OML calculations for stationary and traffic sources have been performed to show their contribution to total concentrations in the urban background. Calculations have been performed for NO_2 and CO in the Kengarags district where a monitor station also is available.

In figure 2.7 the comparison of average annual concentration from mobile and stationary sources is given for NO_2 and CO, respectively. As it can be seen, the calculated traffic contribution to NO_2 levels in Kengarags is about four times higher than from stationary sources although traffic and industry contributes similar to emissions. The reason is that emission from traffic is emitted at low heights and industrial emissions at elevated heights and hence emission from stacks is diluted more than from traffic. However, note that the NO_2 contributions from stationary and point sources are not directly additive as the NO_2 formation depends on the ozone available. For urban background concentrations of CO, traffic contributes about 20 times more than the stationary sources, although traffic sources only contribute about 2.5 times more to emissions. An emission control strategy that only focused on industrial emissions because it is the dominant source in the emission inventory would be misleading

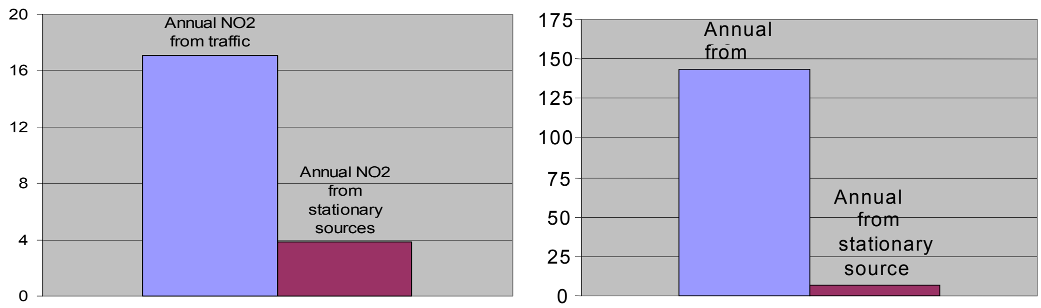

Figure 2.7 NO_2 and CO annual concentrations from mobile and stationary sources in 2000 in µg/m^3.

2.3 Street scale

Selected street canyons

Three street canyons in Riga were selected for assessment of street concentrations; see the location in Figure 2.8. All streets have 5-6 storeys buildings along both sides of the street. The streets represent near worst case situations where some of the highest concentrations in Riga can be expected.

Street configuration data and traffic data were established for the streets.

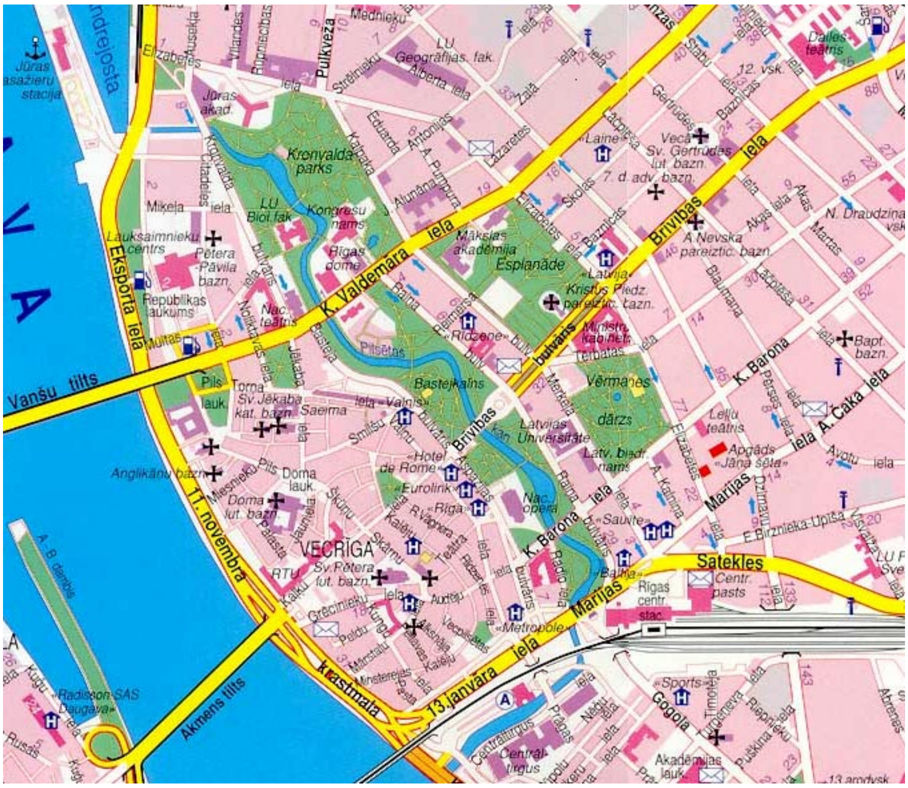

Figure 2.8 Locations of the three selected street canyons in Riga: Valdemara, Brivibas and A. Caka.

2.3.1 Emission estimation for the OSPM model

Emissions were estimated with WinOSPM emission module with COPERT emission factors as described in the previous section.

Diurnal variation of cold starts

The diurnal variation of cold starts for petrol-powered passenger cars is a parameter in the OSPM model that has to be given as a percentage of all petrol-powered passenger cars for each hour. During the cold start period the engine has elevated emissions. A cold engine is defined as an engine that has been turned on less than 2.5 minutes ago and that has not been running for the last two hours. No information is available in Latvia on cold start, and Danish data have been applied. It is recommended that such information is collected for selected representative streets e.g. based on stop interviews of drivers to determine for how long time they have been driving since engine start. This information is not collected as part of the national emission inventory based on the COPERT methodology because cold start information is integrated into the methodology.

2.3.2 Example of model results

The model can calculate hourly concentrations in two receptors positioned at the street level (on both sides of the streets). The street concentrations consist of the contribution from the traffic emissions in the street and the contribution from the urban background. For the urban background monitoring data for 2000 from Kengarags has been used.

NO_2

The results obtained with the model for the NO2 street level concentrations are presented in the table below. The model results are similar for the three selected streets because the traffic levels and the street configuration are similar. In all three streets the annual EU limit value for 2010 for human health protection (40µg/m3) is exceeded.

Table 2.3. The NO_2 annual and hourly average concentration at the street level in 2000. Receptor 1 is here the East side of the streets and receptor 2 the West side of the streets.

Street name	Receptor 1		Receptor 2	
	Annual average [µg/m^3]	The 18'th highest hourly concentration [µg/m^3]	Annual average [µg/m^3]	The 18'th highest hourly concentration [µg/m^3]
Valdemara	48	150	52	151
Brivibas	52	154	56	155
A. Caka	53	153	56	154

2.4 Comparison of regional, urban background and street levels

In the figure below an example of a comparison between regional, urban background and street levels is given. For NO2 the street levels are about twice as high as the urban background and the regional background levels are very low. For CO and benzene, respectively, the streets levels are about 3 and 5 times higher than the urban background, and the regional levels are also expected to be low.

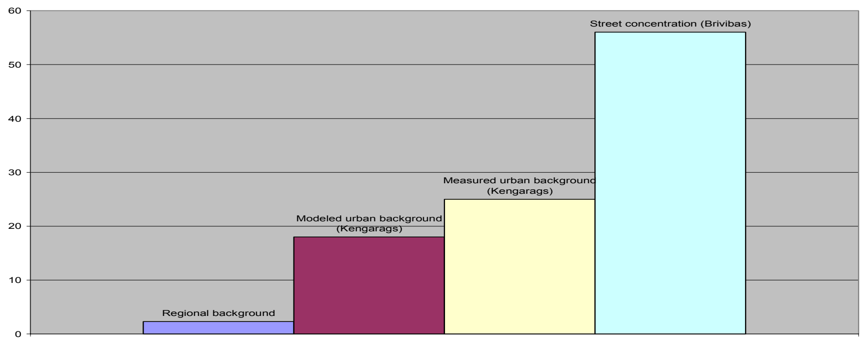

Figure 2.9 Annual NO_2 concentrations at regional (measured), urban background (measured and modelled) and street level (modelled) in 2000 in µg/m^3.

2.5 Assessment of individual industrial point sources

OML calculations were also performed for selected large stationary sources drawn from the LEA/REB emission database. Calculations represent the ground-level concentrations only considering the contribution from each single source (background is not included). The table below is an example for SO_2. Calculated contribution values are compared to Danish limit values. The Danish limit values are not exceeded. The EU limit values for the ambient air is also given as a reference.

Large stationary sources in Latvia. SO2 (values given in µg/m3).

Source	Annual average	3rd highest 24hours conc.	24th highest hourly conc.	Monthly 99-percentiles
TEC2 Acone	0	3	10	11
Siltumtikls Nr.1	0	1	2	2
Cukurfabrika	2	22	67	69
PPBU siltums	4	46	129	140
Parventas siltums	2	23	76	86
Vidzemes piens	1	8	25	26
Tukuma Siltums	1	9	32	33
Tukuma piens	2	15	36	38
Danish C-value				250
EU limit values	20	125	350	

Supplementary parameters

As pointed out earlier the LEA/REB emission database has shortcomings regarding especially gas temperature, gas rate flow and time variation of emissions. It is important to have source specific information about these parameters to get realistic concentration estimates.

In a detailed analysis of the contribution from a single source it is also important to consider the effects of the nearby surroundings – the so-called building effect. A model like the OML model is able to give a crude estimation of these effects. The OML model can handle a number of supplementary parameters which have not been collected so far. These parameters include:

- General effective building height (see below)
- Directional depending building height.
- Horizontal outlet (an option instead of vertical outlet)

The general effective building height and directional depending building height describe the building effect. This effect can have very high impacts on concentrations close to the source. Data is not available on the horizontal outlet (an option instead of vertical outlet). However, horizontal outlets are rare.

It is not necessary to collect these supplementary parameters as part of an assessment of urban background concentrations, but for assessment of the contribution from a single source they should be collected if the model used for the assessment is able to handle the information.

2.6 Regulation of individual point sources

The regulation of the emissions from the industry is undergoing modernisation in Latvia. One option would be to make guidelines for regulation of industrial emissions based on application of AQ models like the OML as it is the case in Denmark. As inspiration for the on-going improvement of regulation of point sources in Latvia a brief description will be giving of the principles of regulation in Denmark, see Figure 2.10.

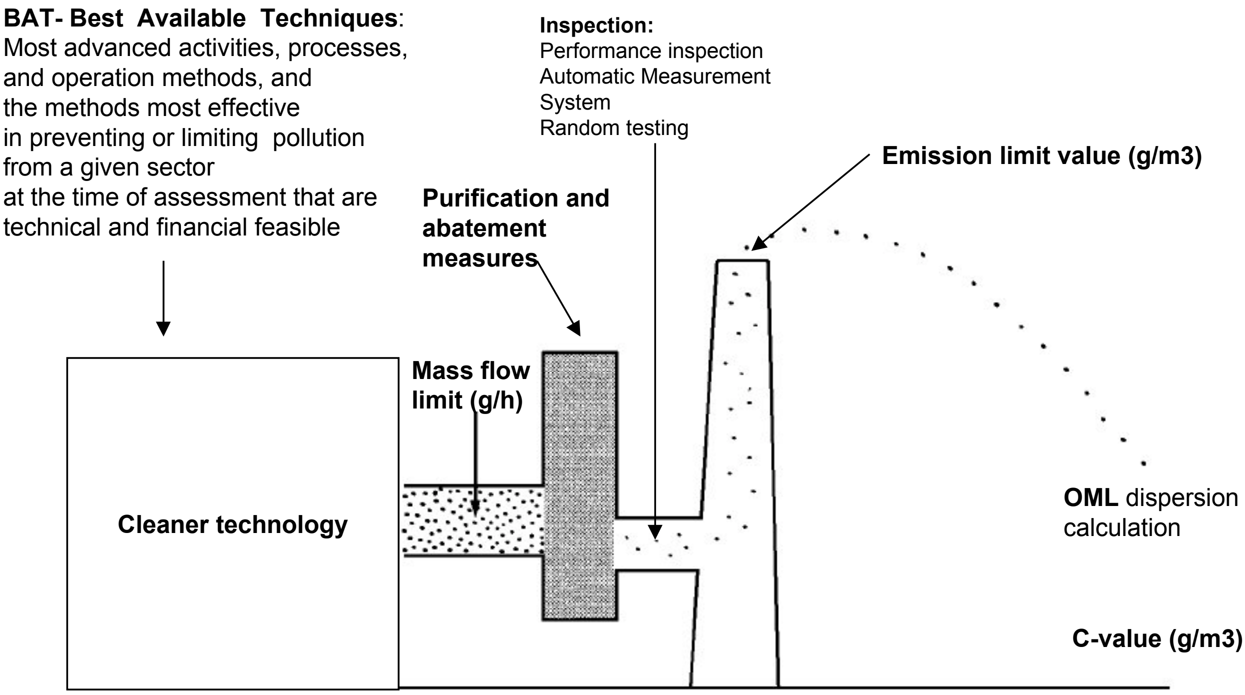

Figure 2.10 Regulation of point sources combines the use of Best Available Technology (*BAT*), emission reduction (mass flow and emission limits) and compliance with Danish EPA limit values for the *contribution* to ambient air concentration (C-values) calculated with the OML model.

Guidelines

The Danish EPA has published a comprehensive report on 'Guidelines to air emission regulation' that describes the regulation in details. This report is available in English from the website of the Danish EPA (www.mst.dk).

Administrative division

Administratively the industrial sources are divided among the present three levels of government in Denmark (State, county and municipality) depending on there size and type.

OML for regulatory use

The Danish EPA requires the use of OML for regulatory purposes in connection with issuing of environmental permits to new industrial sources or major revisions of existing sources.

Principles The regulation combines the use of Best Available Technology (*BAT)*, emission reduction (mass flow and emission limits) and compliance with Danish EPA limit values for the *contribution* to ambient air (C-values).

C-values The OML model is used to calculate stack heights in compliance with Danish EPA limit values (C-values). The C-values are based on the highest monthly 99-percentile (hourly values) and set to minimise human health effects and environmental effects. The regulation only considers one single source at a time. Other industrial sources in the area e.g. neighbouring factories are not considered.

Background air The approach does not consider the contribution from the background air, only the contribution from the single source in question. This approach has more advantages than procedures that attempt to take into account the background air. Firstly, an approach that attempts to take into account the background air has to estimate the background air quality. Technically this can be very difficult and costly e.g. by measurements or modelling, and in many cases it may be impossible to do it on a technically sound basis. It is also an area that opens up for a lot of judgement and potential cheating that can be very difficult to control. Secondly, an approach that takes into account the background air has to have limit values related to the ambient air and not the contribution from the source. In practice this means that different polluting companies are treated with different emission requirements since the contribution from e.g. the first company in an industrial zone may not compromise an ambient air quality limit value while the next company may. The last company would than have to reduce emissions a lot to comply to ambient AQ limits. It is an approach with a built in logic that will allow pollution up to the ambient AQ limits.

An analysis in Denmark has shown that even when modelling the impacts of all sources in an industrial zone the EU directives on air quality for ambient air will not be compromised if all industrial sources comply to the C-values.

Meteorological data The meteorological data required for the modelling in Denmark is based on one available meteorological year (1976 from the airport of Copenhagen) that has been showed to be representative for Danish conditions. This dataset is available together with the OML model, and a similar meteorological dataset has been generated for Latvia using Latvian meteorological data from 1994 based on synoptic data (ground measurements) and radio-soundings (temperature and pressure measurements in the atmosphere).

One may argue that meteorological data should represent the local conditions of the specific location of the point source in questions. However, such an approach is costly and technical difficult if meteorological data has to be generated that represents the location and specific year. It also opens for fiddling because data can be generated and chosen in a way to reduce emission control requirements. It will also treat the industry differently because a more windy location will have less stringent emission control due to more dilution. This may benefit the local environment but total emissions will be higher than it otherwise would be. Latvia is a small country like Denmark and one (or maybe two meteorological datasets to reflect coastal and inland conditions) for one year would be sufficient for regulation of industrial sources.

All in all, the regulation of the industry in Denmark based on the principles outlined has been very effective, it has been administratively simple, cost-effective, and it has treated the industry on equal terms.

3 Recommendations

3.1 Summary

The present report summarises the following activities. The first part illustrates how emission data can be used in AQ assessment on different geographic scales (regional, urban, street and individual industrial sources) and pinpoints what supplementary data is required to be able to utilise emission data for AQ modelling. An assessment has been carried out of the parameters required for air quality modelling and compared to existing emission data to be able to specify supplementary parameters. These supplementary parameters are needed to be collected as part of the national emission inventory with special attention to point sources. A procedure for collection of supplementary data has briefly been discussed. The activity had a very limited time budget that included a presentation on emissions in AQ modelling during the training course 20-23 October 2003 in Denmark for Latvian specialists and writing up the present short report.

To improve future air quality assessment based on modelling it is important that REB/LEA builds up a database that contains necessary parameters for stationary and other sources needed for AQ modelling. In the process of building a national emission inventories based on CORINAIR REB/LEA should supplement their existing database with necessary information needed for AQ modelling and make such data available air quality modelling purposes. Further details are provided in the following.

3.2 Regional scale

GIS based methods for distribution of national emissions on grids

It is recommended that LEA applies GIS methods based on weight themes for distribution of national emissions to the EMEP grid of 50x50 km^2 covering Latvia. This is a formal requirement under EMEP reporting to report emissions on 50x50 km^2.

The Danish National Survey and Cadastre has recently defined a National Square Grid covering all of Denmark. This means that data that has been assigned to the National Square Grid can be exchanged in tabular form. Therefore, it is independent of specific GIS software but can still easily be visualised in any GIS software. It is also recommended that Latvia defines a similar standard National Square Grid to ease data exchange. A national grid will mainly be useful for distribution of emissions on a finer grid resolution than the EMEP grid and would be useful for urban background modelling.

Temporal variation of emissions

It is recommended that LEA establish information about the temporal variation in emissions although it is not yet a formal requirement under the EMEP reporting system. It is not necessary to collect such information for every stack but just for different typical main categories that are substantially different in temporal variation e.g. industrial sources, power plants, heating plants, residential heating, traffic etc. Such information is useful as input at the regional scale, but also for local scale AQ modelling.

3.3 Urban and street scales

industrial point sources

The present emission database for stationary sources at REB/LEA has major limitations concerning the parameters needed for AQ modelling. From an AQ modelling point of view there were limitations of the emission database provided by REB/LEA since it is not possible to partition total emissions from a single source to the different stacks of the source. Furthermore, data is not available on gas temperature and gas flow. This data has been estimated based on best judgement.

For industrial point sources it is essential that an emission database include the following parameters and the exiting emission database should be supplemented with parameters not registered at the moment:

- Location of source (co-ordinates)
- Stack height and diameter
- Emission strength (related to each stack)
- Gas temperature (related to each stack)
- Gas rate flow (related to each stack)
- Time variation (representative for its type).

It will not be very demanding to collect the supplementary information since it should be available from the companies and can easily be collected as part of existing collection procedures.

The existing database includes rather small point sources and there is no need from an AQ modelling point of view to include even smaller point sources.

Residential heating

So far no information has been collected about emissions from individual heating. In a national emission database individual boilers should not be registered as single sources. However, emission data on residential heating should be available on a finer grid resolution of e.g. 1*1 km2 based on weight themes like population, area of residences or alike. This will be very useful for modelling on the urban scale.

Traffic

CSDD provided useful information about car fleet characteristics as input to emission estimation at the local scale. No information was available on engine size for passenger cars. The distribution of engine size was based on information about the mark of cars e.g. VW Polo was assumed to have an engine size below 1.4. Some uncertainties were introduced in this way and CSDD should maintain a database with the data needed for the COPERT methodology that is also the basis for the national emission inventory for vehicles. LEA and CSDD should work out a procedure to ensure that all necessary data on the car fleet is collected for the COPERT methodology. These data are crucial in preparing the national vehicle emission inventory as input to the international convention on long-range transport that Latvia has signed. Furthermore, it is crucial to estimation of emission factors at street level e.g. input to the OSPM model.

The average content of benzene, sulphur and lead in gasoline and diesel has been obtained from LEA based on regulation. However, no information was available on the actual content since no or little control is carried out by the authorities. The content of benzene may be up to 5% but the actual content may be lower. It is important that such information is collected both from a national and a local point of view.

The diurnal variation of cold starts for petrol-powered passenger cars is a parameter in the OSPM model that has to be given as a percentage of all petrol-powered passenger cars for each hour. No information is available in Latvia on cold start and Danish data have been applied. It is recommended that such information is collected for selected representative streets e.g. based on stop interviews of drivers to determine for how long time they have been driving since engine start.

3.4 Assessment and regulation of individual point sources

Detailed analysis of single sources

In detailed analysis of the contribution from a single point source it is also important to consider the effects of the nearby surroundings – the so-called building effect. In this case information has to be collected on building dimensions etc. Such data would be convenient to store in national database on point sources and useful in issuing of environmental permits if emission regulation was based on a model that could take into account building effect. Since building effects are not taking into account in the present regulation there is no need to collect the data.

Regulatory use for AQ models for industrial control

The regulation of the emissions from the industry is undergoing modernisation in Latvia. One option would be to make guidelines for regulation of industrial emissions based on application of AQ models like the OML as it is the case in Denmark. As inspiration for the ongoing improvement of regulation of point sources in Latvia a brief description was giving of the principles of regulation in Denmark. It was argued that the regulation of the industry in Denmark has been very effective, administratively simple, cost-effective and treated the industry on equal terms. It is therefore recommended that Latvia develops similar regulations adopted to Latvian conditions.

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