National Environmental Research Institute
Ministry of the Environment · Denmark

Assistance to Romania on Transposition
and Implementation of the EU
Ambient Air Quality Directives

# Preliminary Assessment based on AQ Modelling

Ploiesti Agglomeration in Romania

*NERI Technical Report No. 435*

*[Tom side]*

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***NERI Technical Report No. 435***
**2003**

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# Data sheet

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|---|---|
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Abstract: This report describes the preliminary assessment of the air quality in Ploiesti agglomeration in Romania based on AQ modelling. The methodology described serves as a role model for future assessments in Romania where Ploiesti has been chosen as a pilot study. The report is the first of its kind in Romania since it is the first time that comprehensive AQ modelling has been applied for assessment. The preliminary assessment is carried out in accordance with the requirements in the EU directives on air quality assessment and management. The four pollutants listed in the first EU daughter directive are covered: $NO_2$, $SO_2$, PM10 and lead. Modelling is based on the Danish models OML for urban background modelling and OSPM for street canyon modelling. Modelled concentrations are also compared with an indicative passive measurement campaign. Modelled and measured concentrations are compared to EU thresholds and limit values.



Keywords: Air quality, modelling, preliminary assessment, EU limit values

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# Contents

# List of abreviations

| | |
|---|---|
| AQ | Air Quality |
| CDM | Climatological Dispersion Model |
| EIA | Environmental Impact Assessment |
| EMEP | European Monitoring and Evaluation Programme |
| EPI | Environmental Protection Inspectorate |
| EU | European Union |
| ICIM | National Institute of Environmental Research and Engineering |
| IDAQ | Assistance to Romania on Transposition and Implementation of EU Ambient Air Quality Directives. |
| INMH | National Institute of Meteorological and Hydrology |
| MWEP | Ministry of Waters and Environmental Protection |
| NERI | National Environmental Research Institute |
| NILU | Norwegian Institute for Air Research |
| OML | Operational Model for Air Pollution |
| OSPM | Operational Street Pollution Model |
| RAR | Romanian Auto Registry |
| TOR | Terms of Reference |
| TSP | Total Suspended Particulate Matter |
| UBM | Urban Background Model |

# Summary

This report describes the preliminary assessment of the air quality in Ploiesti based on AQ modelling. Ploiesti has been chosen as the first case because input data is available for modelling during the mission of February/March 2002. The AQ Assessment Team at ICIM will carry out the preliminary assessment based on modelling for the other pilot regions using the present report as an outline. The preliminary assessment covers the four pollutants listed in the first daughter directive: $NO_2$, $SO_2$, PM10 and lead.

*Preliminary assessment based on AQ modelling*

According to the EU directives a preliminary assessment is defined as: 'Member States which do not have representative measurements of the levels of pollutants shall undertake series of representative measurements, surveys or assessments in order to determine the future requirements of assessment for the zones and agglomerations'.

The preliminary assessment has been based on indicative passive sampling campaigns and AQ modelling since representative high quality monitoring data does not exist in Romania at present. Therefore, AQ modelling has become an important part of the preliminary assessment of air pollution in the selected Pilot areas in the IDAQ project.

*NERI AQ models*

AQ models developed at NERI in Denmark have been applied. The OML model has been used to model urban background concentrations. The OML model is a modern multiple source plume model. The Danish EPA recommends the OML model for regulation of industrial sources in Denmark. The OSPM model has been used to model street concentrations in selected street canyons. The OSPM model is a combined plume and box model describing the main physical and chemical processes in a street canyon. The Danish EPA recommends the OSPM model for AQ assessment in streets. The expert institutions at ICIM should primarily use the dispersion models for AQ assessment according to EU requirements but they could also be used by the local EPIs for air quality management e.g. impact assessment of single point sources for permits, assessment of street concentrations in selected streets etc.

AQ modelling training performed by NERI experts has been provided to Romanian AQ specialists including ICIM experts. The training started with the two-week training course held in Denmark in September 2001. Steen Solvang Jensen from NERI installed the NERI models on the IDAQ computers during his mission in November/December. A two-day training course was also performed in Bucharest in November 2001, also involving more experts from ICIM.

*Input data*

The models require comprehensive input data on source and surrounding characteristics, emissions, meteorology and regional concentrations. All this data have been collected through: EPIs, Municipality of Bucharest, RAR and INMH.

*AirQUIS*

The AirQUIS AQ management system developed by NILU in Norway has been used as a database to store collected monitoring and emission data from point and area sources. Data from the AirQUIS database were prepared for the use in the models. Interfaces between AirQUIS output data and NERI-models input have been prepared.

NERI and AGRARO were introduced to AirQUIS during a four-day training course in Norway in September 2001. A one-day AirQUIS workshop was undertaken with 27 participants from MWEP, ICIM, EPIs and local consultants, and followed up by on-the-job training for the specialists with daily work with AirQUIS. The AirQUIS system was installed at the project office at MWEP 28 September 2001, and on 7 February 2002 it was transferred to the project office at ICIM to serve the ICIM AQ Assessment Team.

*Meteorological data*

INMH has been contracted to provide meteorological data for the OML model based on the OML meteorological pre-processor. A NERI expert Helge Rørdam Olesen has evaluated the data and introduced the ICIM staff to the OML meteorological pre-processor during a short mission in February 2002.

*Traffic data for emission estimation*

RAR has been contracted to provide data on car fleet characteristics from their comprehensive database and temporal variation of traffic for emission estimation together with a simple guideline offered to the EPIs to count traffic in selected street canyons in the pilot regions.

# 1 AQ modelling and the EU directives

*EU directives*

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 the 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 specifically 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. The NERI AQ models meet these requirements.

*Spatial distribution for assessment*

AQ modelling has an important place in preliminary assessment. The use of models enhances the ability to map the spatial distribution of the pollutant concentrations on different scales (from regional background to urban background to streets). Thus, it can provide for an indicative checking of compliance/non-compliance of limit values and an assessment in relation to lower and upper assessment thresholds defined in the directives.

*Designation of zones*

Information on spatial distribution of pollutants may help to designate or alternate zones.

*Optimised monitoring networks*

It also provides for better design of monitoring networks. It opens the possibility of relaxing the measurement requirements (possibility reducing the number of stations), and thus of producing a more optimised cost-effective, and yet complete, air quality assessment. The combined use of monitoring and modelling is an essential part of the overall strategy in the EU directives.

*Action plans*

If Member States exceed the margin of tolerance for the pollutants 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. 'What if' scenarios can be used to evaluate cost effective abatement strategies.

*EU thresholds and limits*

Lower assessment thresholds (LAT), Upper assessment thresholds (UAT), limit values (LV), margin of tolerance and attainment dates for the various pollutants are shown in Table 1.

| Pollutant | Limit Value (LV) ($\mu g/m^3$) | Margin of tolerance<br>% of LV | Lower Assessment Threshold (LAT)<br>% of LV | Upper Assessment Threshold (UAT)<br>% of LV | Averaging time | Statistics | Protection of | Year of Compliance |
|---|---|---|---|---|---|---|---|---|
| $NO_2$ | 200 | 50% | 50% | 70% | 1 hour | 18 times per year | People | 2010 |
| | 40 | 50% | 65% | 80% | - | Annual mean | People | 2010 |
| $NO_x$ | 30 | - | 65% | 80% | - | Annual mean | Vegetation | 2001 |
| $SO_2$ | 350 | 50% | - | - | 1 hour | 24 times per year | People | 2005 |
| | 125 | 65% | 40% | 60% | 24 hours | 3 times per year | People | 2005 |
| | 20 | 65% | 40% | 60% | | Mean, annual and winter | Eco-systems | 2001 |
| Particles ($PM_{10}$) | 50 | 50% | - | - | 24 hour | 35 times per year | People | 2005 |
| | 40 | 20% | - | - | - | Annual mean | People | 2005 |
| | 50 | 2005 LV | 40% | 60% | 24 hour | 7 times per year | People | 2010 |
| | 20 | 50% | 50% | 70% | - | Annual mean | People | 2010 |
| Lead | 0.5 | 100% | 50% | 70% | - | Annual mean | People | 2005 |
| Benzene | 5 | 100% | 40% | 70% | - | Annual mean | People | 2005 |
| CO | 10,000 | 60% | 50% | 70% | 8 hours (running) | Maximum | People | 2005 |

***Table 1*** Limit values, lower assessment thresholds (LAT), Upper assessment thresholds (UAT), limit values (LV), margin of tolerance and attainment dates for the various pollutants

*Combined use of monitoring and modelling*

Figure 1 visualises the combined use of measurements and modelling in AQ assessment under the directives. The different regimes refer to different requirements for assessment methods.

The Preliminary Assessment should describe the zones and agglomerations in these regimes to establish the requirements for future AQ monitoring and modelling according to the EU requirements. Thus, AQ modelling has an important part in the continuous assessment beyond the preliminary assessment. In agglomerations (more than 250.000 inhabitants) monitoring is mandatory and also in non-agglomerations if the assessment shows the state of regime 1. Monitoring can be reduced in regime 2 if supplemented by modelling, and modelling is sufficient in regime 3 or indicative measurements may be used.

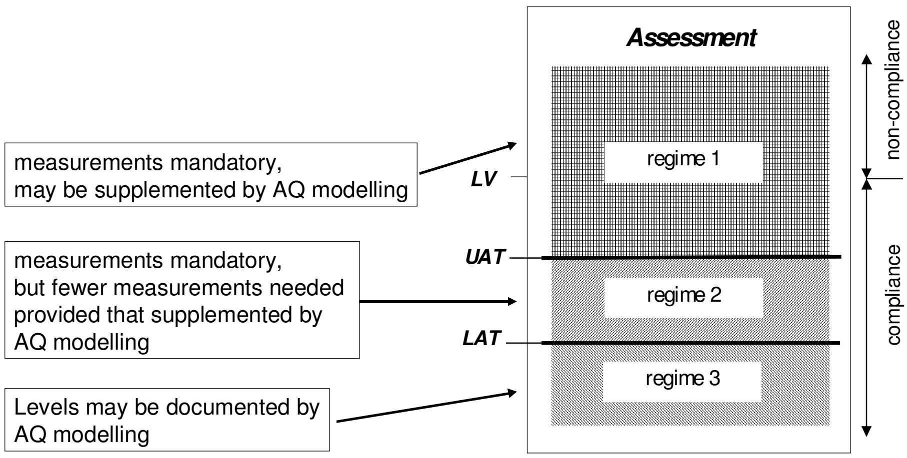


***Figure 1*** Combined use of monitoring and modelling for AQ assessment

*Margin of tolerance and action plans*

Figure 2 shows the requirements for actions plans and reporting in relation to margin of tolerance and limit values.

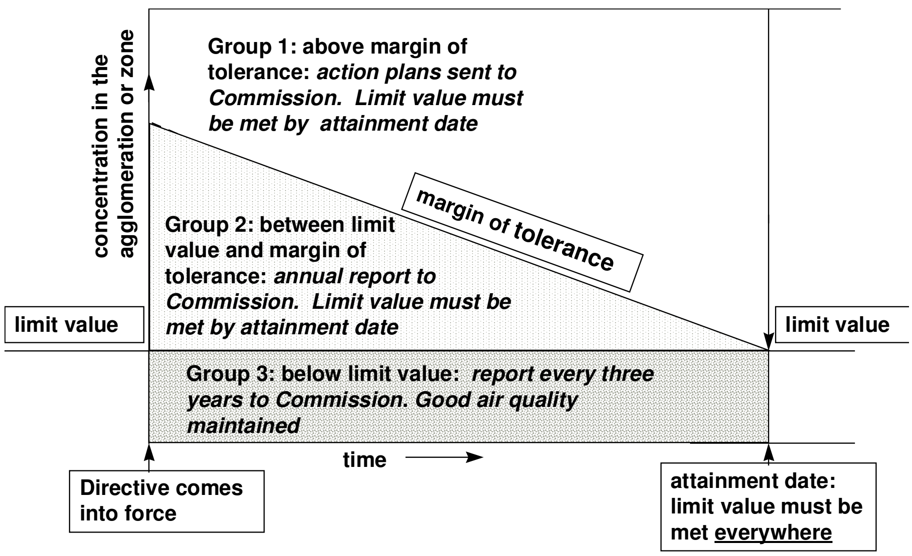


***Figure 2*** Requirements for actions plans and reporting in relation to margin of tolerance and limit values

*Demonstration of AQ modelling in pilot regions*

The application of dispersion models as a supplementary tool for preliminary assessment will be demonstrated in the pilot areas and the use of AQ models as a tool for AQ management will be introduced. The following outcomes will be 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 where sufficient measurement data exists (passive sampling campaign).

# 2 Air Quality Models

## 2.1 NERI dispersion models

*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 nested approach is necessary since street pollution models require inputs about the urban background modelled or monitoring data. The urban background model also requires input about the regional background modelled or monitoring data. 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.

*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.

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 Danish EPA recommended model to be used for environmental impact assessments when new industrial sources are planned in Denmark.
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 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 pre-processor that 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.

The user-interface is a Windows programme running on a PC.

The OML model is described in details in Berkowicz et al (1986), Olesen et al. (1992a,b), Olesen (1993, 1994, 1995).

*OSPM*

The OSPM model is a street canyon model. A street canyon is a street with continuous buildings of several storeys tall buildings at both sides of the street. However, the model can be used for streets with irregular buildings or even buildings on one side only 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 are calculated. In the standard output modelled concentrations are related to EU limits. Substances included are: $NO_2$, ($NO_x$), $O_3$, CO and benzene as well as $SO_2$ and lead.

A module for calculation of transformations of particles in the street air is under development. The exhaust pipe emission of particles from vehicles is well known but still very large uncertainties exist on the contribution of particle re-suspension in streets (road dust etc.).

The COPERT methodology has been implemented as emission module.

The model should not be used for crossings or for locations far away from the traffic lanes.

The user-interface is a Windows programme running on a PC.

The OSPM model is described in details in the references Berkowicz et al. (1997a,b) and Hertel and Berkowicz (1989a,b).

*Input requirements*

The input requirements of the OML and OSPM models are summaries in table 2. A detailed description of the input data requirements for the OML and OSPM is described in two separate notes (Jensen 2001a,b).

*Table 2. Input requirements of the OML and OSPM models*

| Type of input | OML model | OSPM model |
|---|---|---|
| Source | Industrial point sources<br>Location of source<br>Stack height, diameter, type etc.<br>Area sources (heating, traffic) | Line source in streets<br>No. of vehicles in different vehicle categories in street canyons |
| Emission | Emission strength<br>Temperature<br>Gas rate flow<br>Time variation | COPERT III emission factors based on car fleet characteristics (No. of vehicles in emission classes and annual km travelled).<br>Diurnal variations in traffic (number, travel speed, cold starts) |
| Receptor | Circular or grid net<br>Receptor height | Receptor located close to building facade at both sides of the street<br>Receptor height |
| Topography | Terrain height<br>Largest terrain inclination<br>Effective building height<br>Directional dependent building height<br>Aerodynamic roughness length<br>Release height and building height for area sources | Street configuration data<br>- general building height<br>- building height in wind sectors<br>- street orientation and width<br>- distance to street intersections |
| Meteorology | Pre-processed hourly meteorological data from synoptic met. station and twice-daily vertical temperature profiles from radio-probe stations | 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 NILU Air Quality models

The GIS based platform AirQUIS, which include emission inventories, monitor data and dispersion and exposure models will be used for air quality planning purposes, is a management and decision support system. AirQUIS has been developed by Norwegian Research Institutes and includes AirQUIS, which is an air pollution related module which can be used as a management tool for planners, as an information tool for the public and as an expert system for specialists.

The GIS based AirQUIS system includes several modules that can be selected and applied according to the user's needs. Important common parts are the measurement database, and the graphical user interface including the GIS (geographical information system). (see Figure 3).

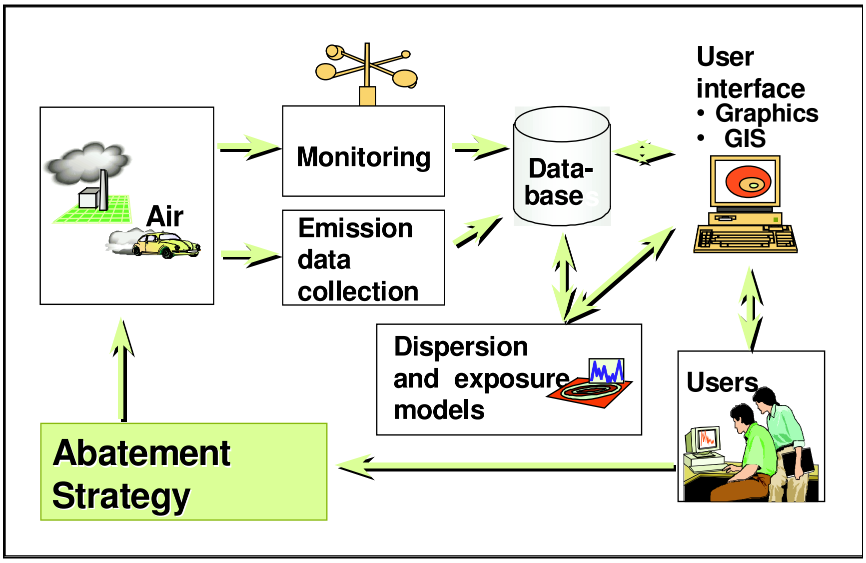


*Figure 3* AirQUIS Sytem modules

The user interface is to a large extent a map interface from which spatial distribution of pollution sources, monitoring stations, measurements, model results and other geographically linked objects can be presented. The map interface can also be used as an entrance for making queries to the database

The GIS (Geographical Information System) functionality of the AirQUIS system is designed to offer several possibilities for understanding the problems of air pollution.

- The GIS makes it easier to place the air pollution sources at the correct location, for example by making it easy to display the total network of road links in a city.
- GIS presentation of area-distributed consumption of fossil fuels and direct emissions gives a good overview of where to expect high impact of air pollution.
- Viewing the measurement stations on a map with the pollution sources will give an idea of what concentrations one may expect to find at the stations for a given wind direction.
- The GIS makes it easier to search for geographically linked data in the database.
- Displaying results of model calculations as a map can be used for public information on pollution levels at different parts of a city.

**AirQUIS** consists of six components and makes use of an Oracle database. The system has integrated forms and maps, was developed in Visual Basic and Map Object (GIS) and works well on an ordinary NT-server. The different components consist of:

- A manual data entering application,
- An on line monitoring system,
- A module for online data acquisition and quality control,
- A measurement data base for meteorology and air quality,
- A modern emission inventory data base with emission models,
- Numerical models for transport and dispersion of air pollutants,
- A module for exposure estimates and population exposure assessment,
- Statistical treatment and graphical presentation of measurements and modelling results,

All objects described above are integrated in a map and menu oriented user-friendly interface with direct link to the databases for measurements, emissions, modelling results and presentation tools. Advanced import/export wizards allow the user to transfer data easily to and from the AirQUIS system. ENSIS/AirQUIS has tools for graphical presentation and control of data, and tables for numerical presentation of data and statistical summaries. The information system provides a report generator and the possibility of exporting data and map images

The IDAQ project will use for the assessment study the AQ measurement data base module and the emission inventory database. The emission inventory module is structured based on the following approach.

The sources of air pollution are divided in three categories. Emissions from single activities of some size, like industries, energy production etc., that are linked to single stacks, are treated as point sources. Emissions from home heating, public and private services, diffusive ground level emissions at large industrial complexes, agricultural activities etc. are treated as area sources. Emissions from road traffic are treated as line sources in the emission database.

Regardless of being point, line or area distributed, emission data can be found either as emission data for different components, or as a set consisting of consumption data and emission factors for the components for different fuels and activity types.

The emission data usually comes as yearly data, and a time factor is used to find the fraction of the yearly value that is valid for a specific period within the year. This information could relate to typical diurnal variations, weekly variations or monthly variations in emission rates. A set of these time factors is part of the emission module in AirQUIS.

The database for road traffic emissions, line sources, includes the geographical and physical description of the roads (road link definition), a system for classifying roads and traffic, dynamic traffic data, and traffic emission factors and dependencies.

The traffic emissions on each road link are calculated by scaling the traffic volume for each vehicle class with a product of traffic emission dependency factors. The value of each of these factors depends on different properties of the vehicle class and the road link. The information about and connections between the different road link and vehicle class properties are defined in the module called Traffic Emission Factors.

Since the traffic emission factors and dependencies are part of the emission database, the ENSIS system makes it possible for the user to modify the emission factors and also to have different alternative sets of factors. This makes it possible to not only study emission scenarios based on different road and traffic alternatives, but also to study effects of technology changes of the cars and to handle local conditions that affects the emissions

The dynamic traffic data describes the traffic flow and vehicle distribution on each road link. The traffic flow is given by annual daily traffic, vehicle distribution and traffic time variation for each vehicle class, in addition to free flow speed. Queue situations where traffic speed is low are described by lane capacity and volume delay functions.

The AirQUIS area sources are based on regional data set consisting of either emission data for different components or consumption data for different source categories for different fuels, with the corresponding emission factors. The area source may even be quantified based on a regional or sub-area based data set of production data, with corresponding emission factors.

A user friendly interface for exporting the emission data from AirQUIS into the OML input data has been programmed by NILU experts during the project work.

# 3 Input data

This chapter focuses on a description of the methodology for providing input data for the OML and OSPM models. It is not within the scope of this chapter to present in details all the collected data.

## 3.1 Emission inventory for the OML model

Point and area source data have been collected by the Pilot EPIs based on templates presented by the IDAQ consultants based on AirQUIS input and OML models input requirements. All data is stored in the AirQUIS system.

*Point sources*

About 100 point sources have been identified for Ploiesti. The location of the point sources is shown in Figure 4. Most point sources are located in the outskirts of Ploiesti.

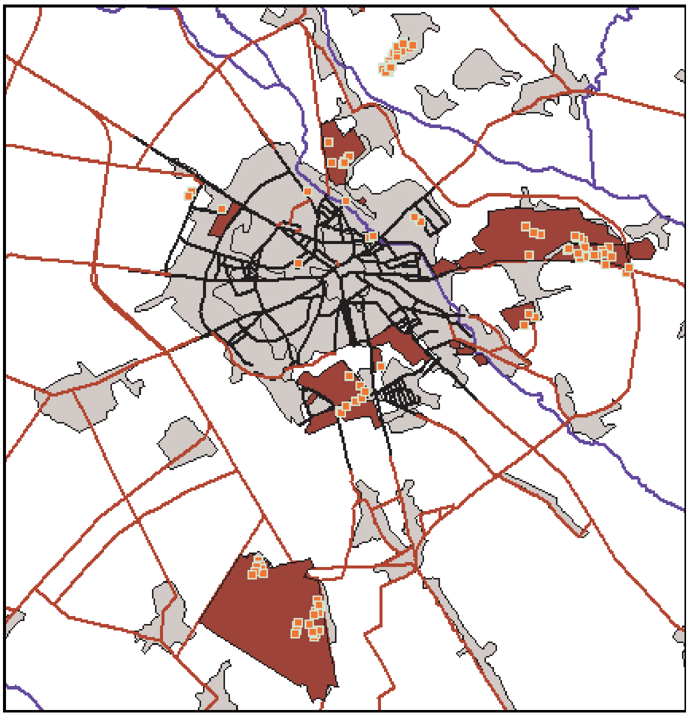

***Figure 4*** Location of point sources in Ploiesti

The emission estimation is based on fuel consumption for the various processes and emission factors defined by the EPIs based on AP42 and CORINAIR. No emission measurements are available.

The distribution of total emissions on the different industrial categories is summarised in Table 3.

*Table 3. Contribution of total emission on the different industrial categories*

| Industrial categories | N0x (tonnes/year) | $SO_2$ (tonnes/year) | PM10 (tonnes/year) | Lead (kg/year) |
|---|---|---|---|---|
| Power plants | 3560 | 5934 | 504 | 436 |
| Refineries - burning processes | 5154 | 8659 | 204 | 64 |
| Refineries - technological processes | 1799 | 5802 | 15307 | 0 |
| Smelters | 6 | 1 | 46 | 1 |
| Other industries | 55 | 81 | 197 | 110 |
| Total | 10574 | 20477 | 16258 | 611 |

*Supplementary parameters not collected*

The OML model can handle a number of supplementary parameters which have not been collected so far and which can not be stored in the AirQUIS system. These parameters include:

- Outer stack diameter (m)
- Horizontal outlet (an option instead of vertical outlet)
- General effective building height (see below)
- Directional dependent building height.

The outer stack diameter determines the down wash. The emission of this parameter is estimated to have a minor influence on concentration levels and can be omitted for preliminary assessment.

Data is not available on the horizontal outlet (an option instead of vertical outlet). However, horizontal outlet is rare and can be disregarded for the preliminary assessment.

The general effective building height and directional depending building height describes the building effect. This effect can have very high impacts on concentrations close to the source.

*Heating as area sources*

The emission estimation for heating is based on fuel consumption and emission factors defined by EPI AP42 and CORINAIR. Emission of the various pollutants is proportional to the fuel consumption.

The distribution of total emissions on the different space heating categories is summarised in Table 4.

*Table 4. The distribution of total emissions on the different space heating categories*

| Space heating categories | $NO_x$ (ton/year) | $SO_2$ (ton/year) | PM10 (ton/year) | Lead (kg/year) |
|---|---|---|---|---|
| Natural gas consumption – apartments | 4.85 | 0.03 | 0.39 | 0.03 |
| Natural gas consumption – house heating | 0.18 | 0.00 | 0.01 | 0.00 |
| Natural gas consumption – cooking | 9.71 | 0.06 | 0.79 | 0.05 |
| Natural gas consumption – small private institutions – heating | 6.42 | 0.01 | 0.14 | 0.01 |
| Natural gas consumption –institutions – heating | 19.86 | 0.03 | 0.42 | 0.03 |
| Natural gas consumption – industry – heating | 66.38 | 0.11 | 1.41 | 0.09 |
| Wood consumption – house heating | 2.87 | 0.00 | 11.27 | 0.00 |
| Heavy oil consumption – house heating | 1.32 | 1.98 | 5.06 | 0.71 |
| Total | 566 | 123 | 266 | 92 |

The spatial distribution of fuel consumption is shown in Figure 5. The highest emissions take place in the central part of Ploiesti.

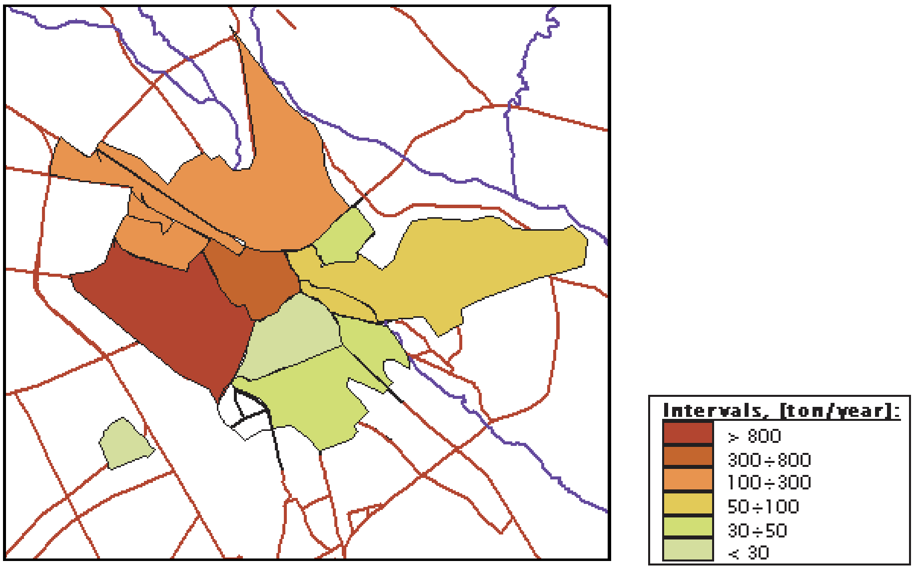


*Figure 5* An example of spatial distribution of fuel consumption from space heating in Ploiesti – natural gas consumption from apartments

*Traffic as an area source*

Traffic as a line source has only been obtained for selected streets. Traffic data has been obtained for some of the main streets in Ploiesti and emissions have been estimated based on emission factors for these limited streets.

For the rest of the road network, emissions have been estimated based on data on total number of vehicles, annual mileage and COPERT emission factors. The AQ expert from AGRARO, George Mocioaca has programmed the COPERT methodology in Excel for estimation of vehicle emission as on area source. For the time being the emission factors only include hot emissions but cold emissions and mileage correction will be implemented at a later stage.

To obtain a spatial distribution, emissions have been distributed according to the total road length of each grid cell and a classification of the roads according to expected traffic levels (George Mocioaca, Octavian Datculescu). Four road classes have been applied: Traffic in suburban areas (1), streets in residential areas (2), through roads (3) and roads in central urban areas (4), the traffic weighting factor is given in the brackets. The traffic weighting factor has been estimated based on the traffic for the selected roads where traffic data is available. The total length in each grid cell has been calculated using ArcView GIS (Steen Solvang Jensen).

The line and area sources have been joined to form one traffic area source.

The distribution of total emissions on the different vehicle categories is summarised in Table 5.

**Table 5**. *The distribution of total emissions on the different vehicle categories*

| *Vehicles categories* | *$NO_x$ (ton/year)* | *$SO_2$ (ton/year)* | *PM10 (ton/year)* | *Lead (kg/year)* |
|---|---|---|---|---|
| Passenger cars | 502 | 33 | 18 | 2522 |
| Light duty cars | 36 | 3 | 3 | 113 |
| Trucks | 18 | 2 | 2 | 0 |
| Buses & coaches | 46 | 4 | 2 | 0 |
| Total | 602 | 42 | 25 | 2635 |

The spatial distribution of NOx emissions is shown in Figure 4.3. The highest emissions take place in the central part of Ploiesti and along the main roads.

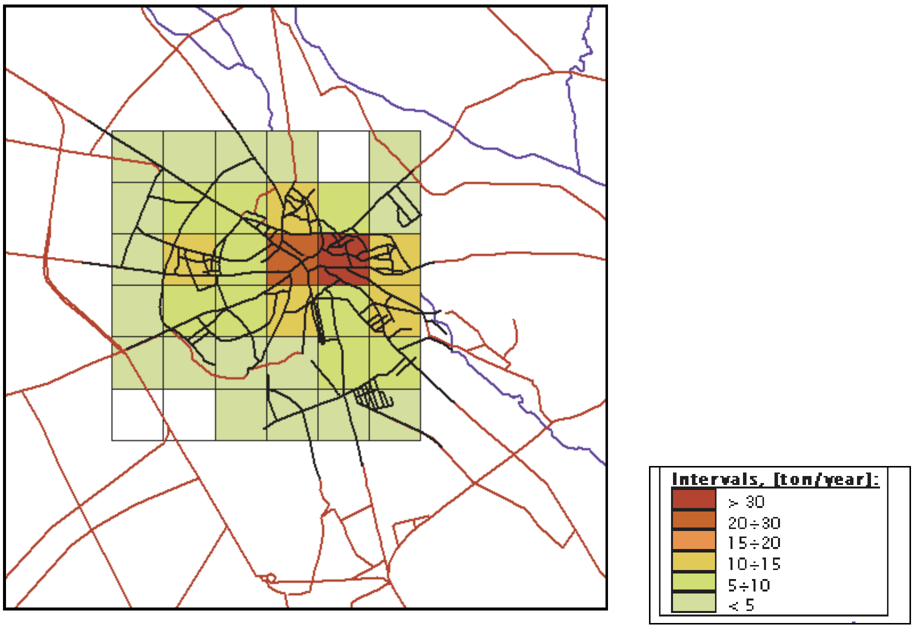


*Figure 6* Spatial distribution of $NO_x$ emissions from traffic in Ploiesti

The contributions of emission from different types of sources (point sources, heating sources, traffic) are presented in the figures 7 – 10. It can be noticed that the contribution of total emissions for $NO_x$, $SO_2$, PM10 comes from the point sources (industry), while the contribution for Lead comes from traffic.

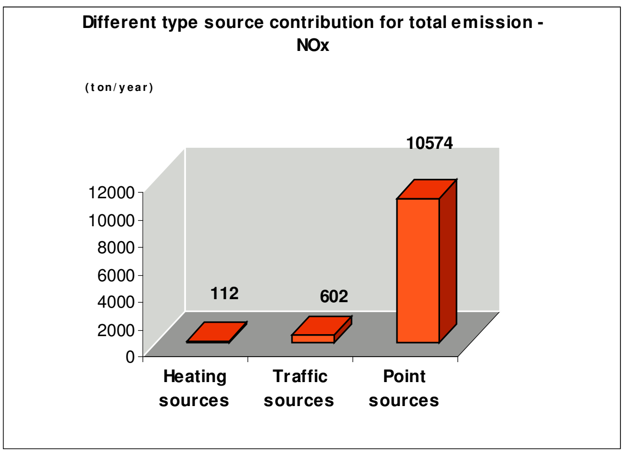


*Figure 7* Contribution of different types of sources for $NO_x$

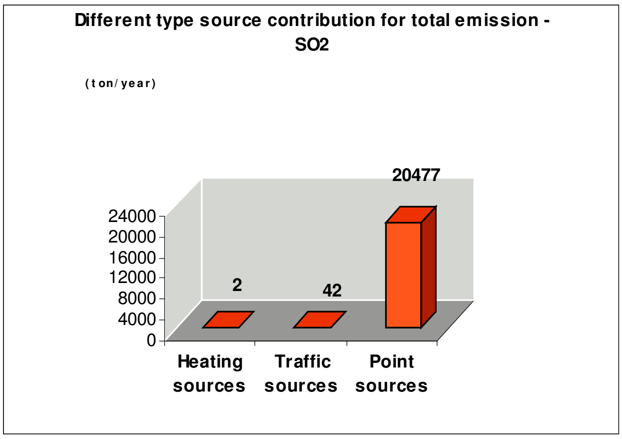


*Figure 8* Contribution of different types of sources for $SO_2$

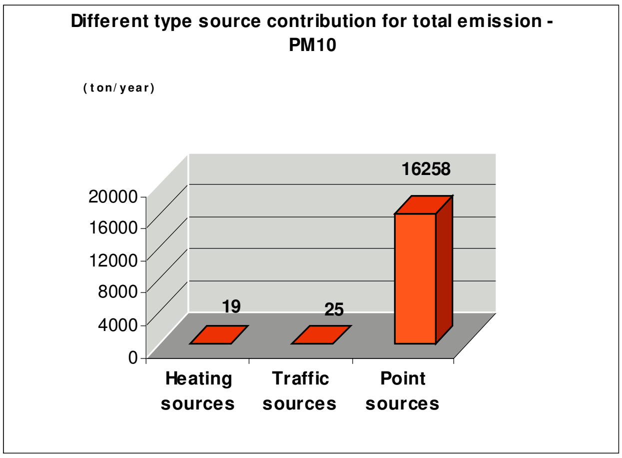


*Figure 9* Contribution of different types of sources for PM10

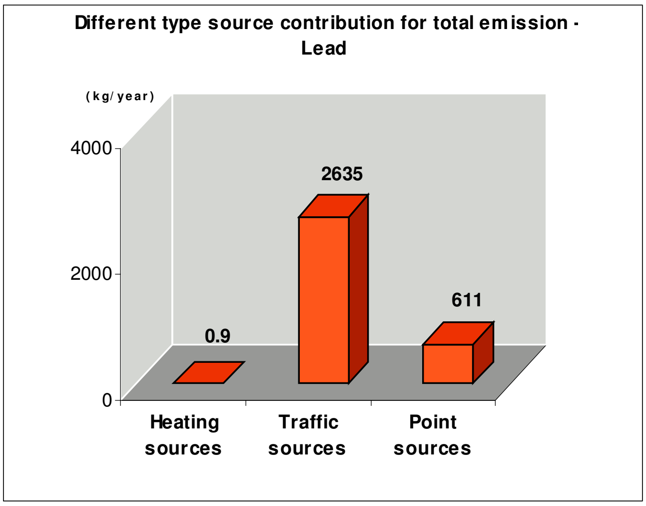


*Figure 10* Contribution of different types of sources for Lead

## 3.2 Regional background data for the OML model

The OML model requires hourly time-series of the pollutants $O_3$, $NO_x$, $NO_2$ as well as $SO_2$, PM10 and lead for the regional background. Since there is a very strong link between the meteorological conditions and concentration levels, the regional background data has been obtained for 2001, the same year for which meteorological data is available.

*Approach*

Romania had six EMEP station in operation 1980-87 but unfortunately the stations have been abolished. Therefore, it has been necessary to obtain regional background data for other sources. Modelled regional background data produced in Romania does not exist. However, modelled data could be obtained through EMEP or e.g. NERI that also operates a regional background model. However, this option has been rules out due to the costs involved.

*Hungarian EMEP station*

Instead, EMEP monitoring data has been obtained from Hungary which is assumed to be representative for Romania. EMEP data for 2001 for $O_{3,}$ (hourly),$NO_2$ (daily) and $SO_2$ (daily) has kindly been delivered by Dr. Laszlo Haszpra and Dr. Krisztina Labancz, Hungarian Meteorological Service, Institute for Atmospheric Physis, Budapest, Hungary.

The location of the EMEP station in Hungary (HU02) is shown in Figure 11.

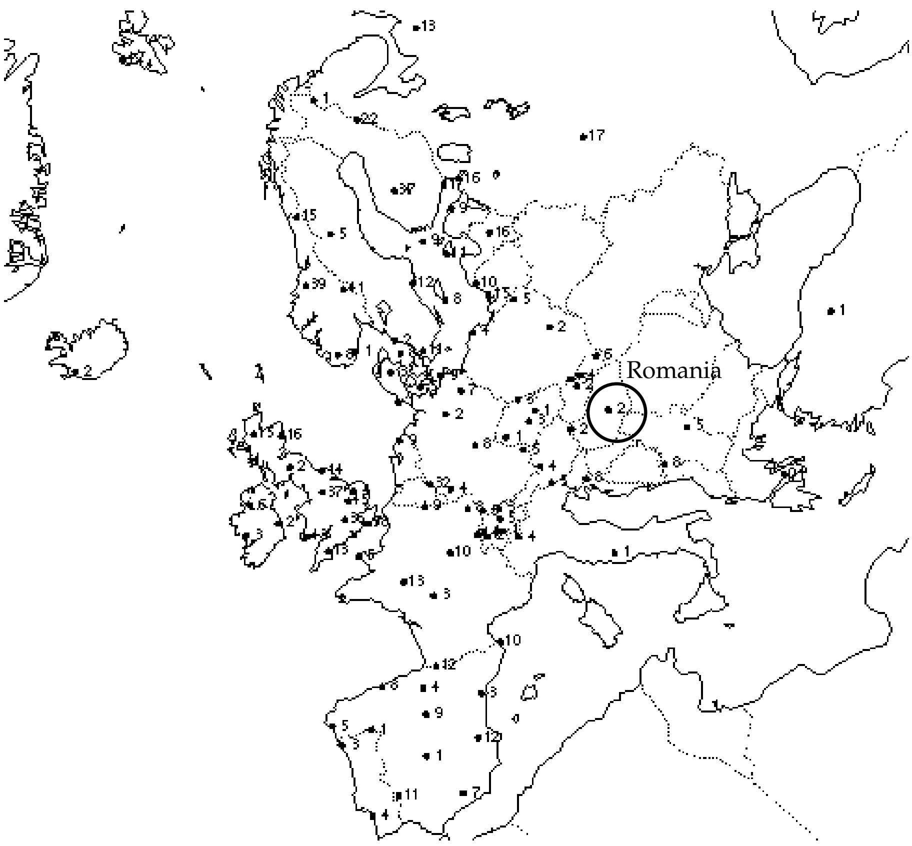


***Figure 11*** EMEP stations adjacent to Romania. Station No. 2 in Hungary (HU02) close to the Romanian boarder has been chosen to represent regional background for Romania

*EMEP monitoring data for $NO_2$, $SO_2$ and $O_3$*

$NO_2$ is only sampled daily and no NOx measurements are carried out. However, in the regional background it is reasonable to assume that almost all NOx is on the form of $NO_2$, thus, NOx levels have been assumed to be equal to $NO_2$ levels. The diurnal variation of $NO_2$ is determined by long-range transport and it is fair to assume that it is constant for the purpose of modelling. An hourly time-series has been generated based on these assumptions.

$SO_2$ is also sampled daily. The EU limit value is related to peak values. The diurnal variation of $SO_2$ is determined by long-range transport and it is fair to assume that it is constant for the purpose of modelling. An hourly time-series has been generated based on these assumptions.

Hourly data for $O_3$ has been obtained.

In the case of missing values, values have been generated based on the interpolation taking into account adjacent observations.

*PM10*

Suspended particulate matter (SMP) is usually sampled daily but not at the Hungarian station. A report (EMEP 2001) has been downloaded from the website of EMEP ( www.nilu.no/projects/ccc). PM10 has been modelled for Europe, see Figure 12.

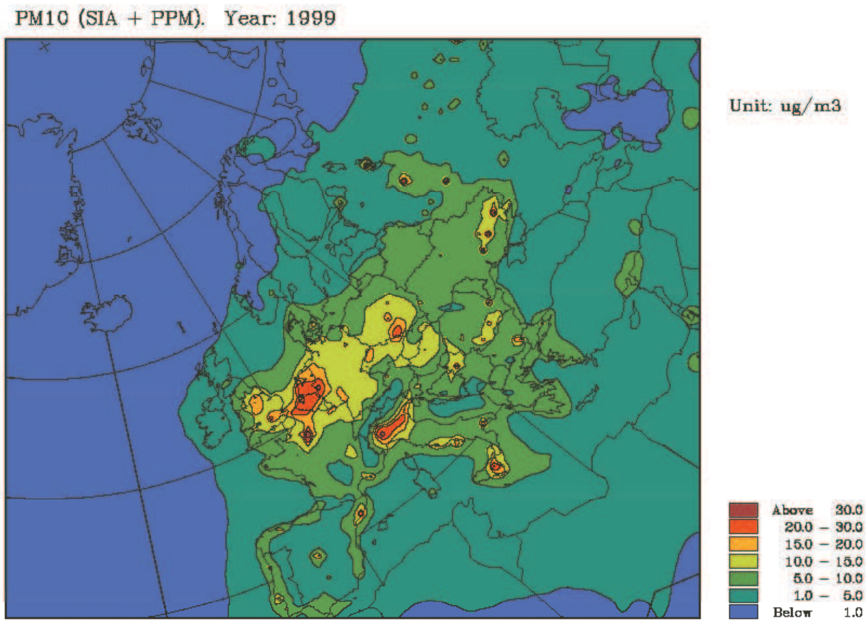


***Figure 12*** Modelled annual PM10 levels in Europe in 1999

*Annual level of PM10*

Modelled annual PM10 levels for Ploiesti are 10-15 µg/m$^3$. However, model results are underestimating compared to measurements. For Switzerland which is close to Romania it is a factor of about two, see Figure 13. Thus, annual PM10 levels for Ploiesti have been assumed to be 12.5 * 2 = 25 µg/m$^3$. This is obviously a very crude estimation.

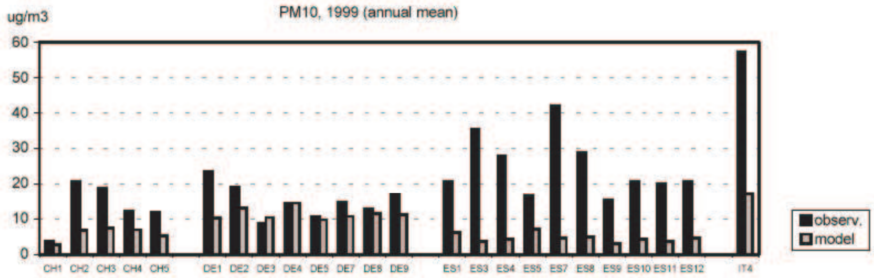


***Figure 13*** Validation of modelled annual PM10 levels in 1999 against measurements. Ch stands for Switzerland.

*Seasonal variation of TSP*

To obtain a seasonal variation, TSP data from the Hungarian EMEP station HU02 was downloaded from the EMEP website. TSP data is available for 1990-1995. An average seasonal variation was established based on this data assuming that the seasonal variation for TSP and PM10 is the same. An hourly time-series has been generated that simply assume the same hourly level of $\mu g/m^3$ for each month taken into account the seasonal variation in monthly levels.

*Lead*

Lead in aerosols from 1999 has been measured at four stations in Slovakia which is the closed location to Romania, see Figure 14. Three of the stations have more or less the same levels which have been used to represent Romania. The annual level is 15 $ng/m^3$, equivalent to 0.015 $\mu g/m^3$. The maximum is between 30 and 85 $ng/m^3$. An hourly time-series has been generated that simply assumes an hourly level of $\mu g/m^3$ for every hour of the year.

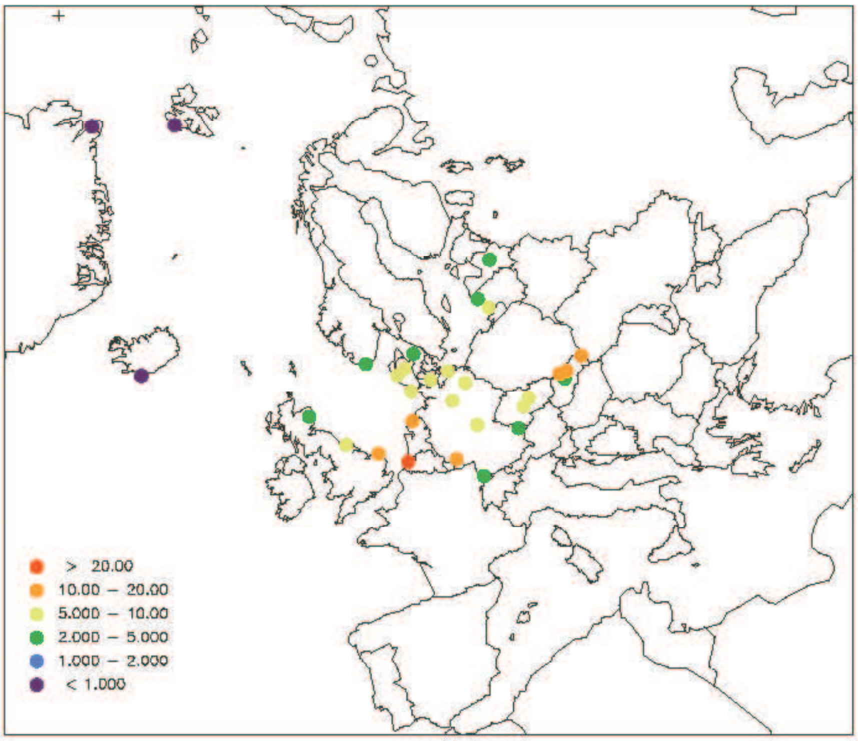


***Figure 14*** Annual lead concentrations in aerosols in 1999 in Europe ($ng/m^3$)

## 3.3 Meteorological data for the OML

INMH has been contracted to provide meteorological data for the OML model based on the OML meteorological pre-processor (Olesen and Brown 1992). The dataset describes the meteorological characteristics of the boundary level where mixing of pollutants take place. INMH has provided met data based on synoptic stations (ground station) and radio-probe soundings (temperature profile etc. in the atmosphere). OML met datasets have been generated for each of the pilot regions.

A NERI expert Helge Rørdam Olesen evaluated the data and introduced the ICIM staff to the OML meteorological pre-processor during a short mission in February 2002. The synoptic observations show many calm conditions with zero wind speed and wind direction due to insensitive instruments. A program has been written to generate values for these conditions. It is based on random generation that takes into account previous and later observations around missing values. For Bucharest this problem will be solved since a modern high sensitive meteorological mast will be available.

## 3.4 Street configuration and traffic data for the OSPM model for selected street canyons

*Selected street canyons*

Four street canyons in Ploiesti have been selected for the assessment of street concentrations - see the location in Figure 15.

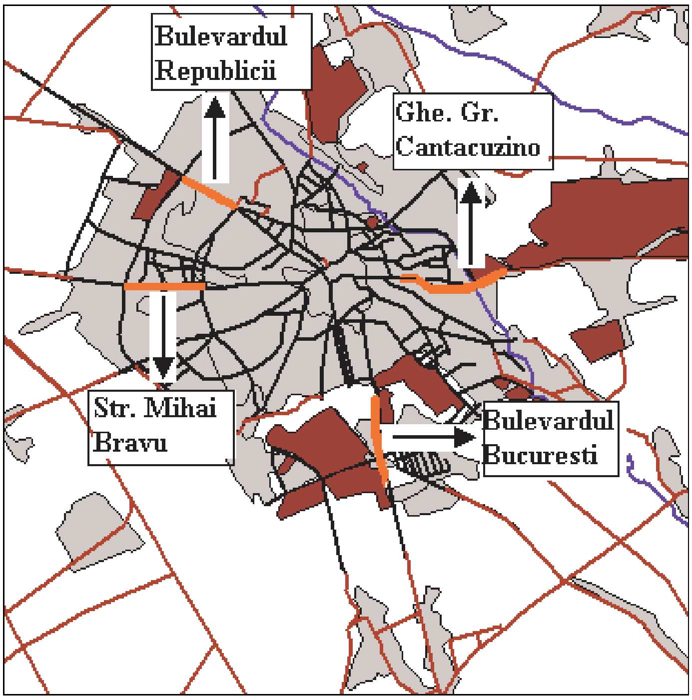


*Figure 15* Location of the four selected street canyons in Ploiesti

*Street configuration and traffic data*

The main street configuration characteristics are shown in Table 6 and traffic data in Table 7. The number of vehicles in each vehicle class is estimated based on the Average Daily Traffic (ADT) for the total traffic and the vehicle composition in percent.

***Table 6*** Street configuration characteristics for selected street canyons in Ploiesti

| | ***Street orientation (degrees)*** | ***Length of street section (m)*** | ***Street width (m)*** | ***Building height (m)*** |
|---|---|---|---|---|
| Bulevardul Republicii | 110 | 388 | 12 | 30 |
| Bulevardul Bucuresti | 180 | 355 | 12 | 27 |
| Strada GHE. GR. Cantacuzino | 90 | 173 | 12 | 18 |
| Strade Mihai Bravu | 90 | 140 | 10 | 15 |

***Table 7*** *Traffic characteristics for street canyons in Ploiesti*:

| | Bulevardul Republicii | | | Bulevardul Bucuresti | | | Strada GHE. GR. Cantacuzino | | | Strade Mihai Bravu | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Vehicle categories: | Vehicle composi-tion (%) | Average Daily Traffic | Travel speed (kmh) | Vehicle composi-tion (%) | Average Daily Traffic | Travel speed (kmh) | Vehicle composi-tion (%) | Average Daily Traffic | Travel speed (kmh) | Vehicle composi-tion (%) | Average Daily Traffic | Travel speed (kmh) |
| Passenger cars | 85 | 20400 | 50 | 85 | 20400 | 50 | 80 | 19200 | 50 | 70 | 16800 | 50 |
| Vans | 8 | 1920 | 50 | 8 | 1920 | 50 | 8 | 1920 | 50 | 4 | 960 | 50 |
| Trucks | 5 | 1200 | 40 | 5 | 1200 | 40 | 10 | 2400 | 40 | 25 | 6000 | 40 |
| Buses | 2 | 480 | 40 | 2 | 480 | 40 | 2 | 480 | 40 | 1 | 240 | 40 |
| Total | 100 | 24000 | | 100 | 24000 | | 100 | 24000 | | 100 | 24000 | |

## 3.5 Emission estimation for the OSPM model

RAR has provided data on car fleet characteristics and temporal variation of traffic for emission estimation, together with a simple guideline (Datculescu 2001a) offered to the EPIs to count traffic in selected street canyons in the pilot regions. Data have been obtained for 2001, and also for 2005 and 2010 to allow for predictions.

*Temporal variation of traffic*

In the OSPM model the temporal variation of the traffic is given by pre-defined files for different types of streets.

For Romanian conditions diurnal variations have been established for: Monday-Friday, Saturday and Sunday for the different vehicle categories for just one representative urban street in Ploiesti and further broken down to July and other months than July. For weekdays the diurnal variation for the various vehicle categories is based on traffic counts in Ploiesti (Datculescu 2001b). No data is available on the diurnal variation of the various vehicle categories on Saturday and Sunday. However, data is only available for Saturdays and Sundays for the total traffic which has been assumed to be equivalent the diurnal variation in passenger cars. Since total traffic is dominated by passenger cars, and passenger cars and other categories have very different diurnal variations, then the diurnal variation other categories can not be assumed to be the same passenger cars. Therefore, the diurnal variation of vans, trucks and buses on Saturdays and Sundays has been assumed to be similar to Danish conditions.

As an example the diurnal variation on working days for the various vehicle categories is shown in Figure 16. The jagged shape of the curves is due to incomplete measurement procedures and data coverage.

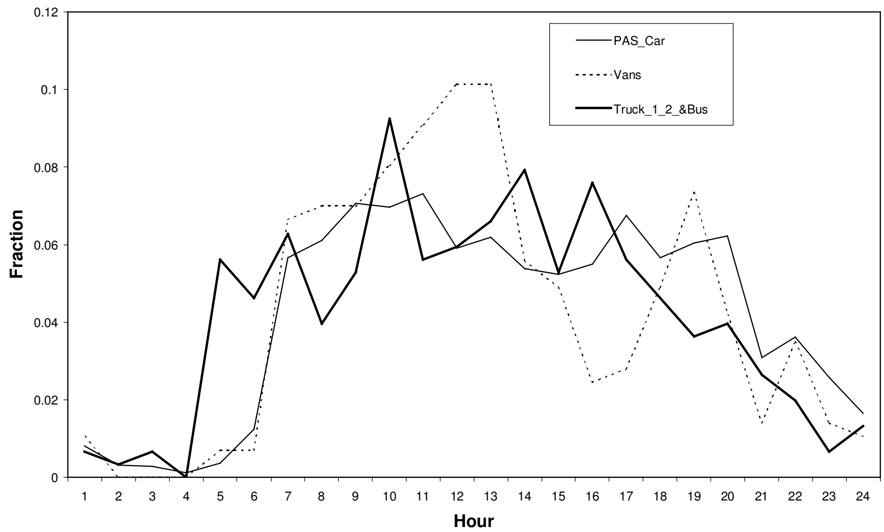


***Figure 16*** The diurnal variation on working days for the various vehicle categories in Ploiesti

The seasonal and weekly variation is described with factors in relation to ADT. Data on seasonal and weekly variation has been obtained from Ploiesti EPI.

*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. 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 Romania on cold start and Danish data has been applied.

*Diurnal variation of travel speeds*

The diurnal variation of travel speeds for passenger cars and vans (V_short) and for lorries and buses (V_long) also have to be generated for typical urban conditions on an hourly basis. No data is available for Romanian conditions and Danish data has been used.

*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, and buses. A data set has been established for the Romanian car fleet to reflect the pilot regions of Ploiesti and Bacau/Neamt. A separate data set has been made for Bucharest that has a different car fleet compared to the rest of the country (Datculescu 2001c,d,e). Car fleet data has also been obtained for 2005 and 2010 to allow for predictions (Datculescu 2001g,h).

COPERT deterioration factors are related to the fraction of vehicles *above* average vehicle mileage of 120,000 km for EURO I and II petrol-powered vehicles. The fraction of vehicles above average vehicle mileage of 120,000 km is called *P_above*. The average vehicle mileage is called AVM and AVM equals average *accumulated* km travelled for each emission class. This data has been obtained (Datculescu 2001g,h).

*Emission modification*

RAR has performed emission measurements of vehicles at chassis dynamometers. According to these measurements, RAR has concluded that all petrol-powered passenger cars of PRE ECE, ECE 15-00/01, ECE 15-02, ECE 15-03 and ECE 15-04 reflect the emission standard that corresponds on average to ECE 15-00/01 emission class. This is due to the obsolete manufacturing level, bad repair and maintenance, low quality fuels, lack or malfunction of the anti pollution systems and so on. For conventional passenger cars, vans, heavy trucks and buses vehicles, RAR has concluded that particulate emission should be 2 times higher than COPERT. These assumptions have been implemented in the emission module of the OSPM model by modifying the default emission factors given in COPERT (Datculescu 2001c).

*Fuel characteristics*

The average content of benzene, sulphur and lead in gasoline and diesel has been obtained (Datculescu 2001f).

## 3.6 Meteorological and urban background data for the OSPM

*Meteorological data*

The meteorological data set prepared for the OML model has also been used for the OSPM model. The OSPM model only requires selected parameters (wind speed, wind direction, temperature, humidity). The OPSM model also requires data on global radiation which has been obtained for two locations in Romania to represent the different pilot regions.

*Urban background data*

The OML calculates urban background concentrations for Ploiesti on a grid. The grid cells that represent the location of the four street canyons have to identified, and modelled data from these grid cells represents the urban background data for the OSPM model.

# 4 AQ Model Results

## 4.1 Model Area

*Model grid*

The OML model has been run on a rectangular grid of 17 km x 17 km. A number of 1225 receptors from 500 m to 500 m east and north have been used for computing the concentration field. The model area is presented in the figure below.

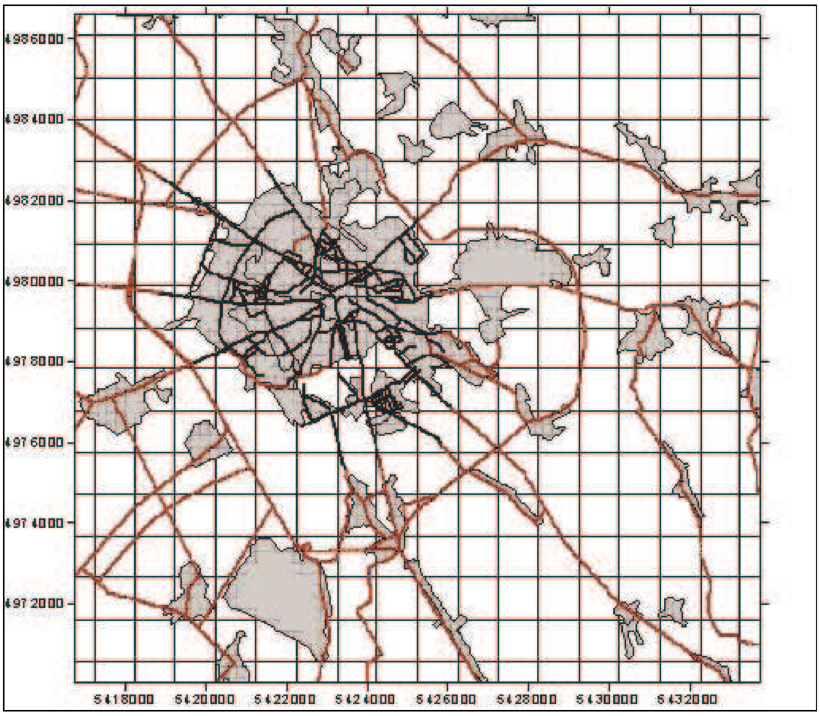


***Figure 17*** The modelling area for Ploiesti (Gauss-Kruger coordinates)

## 4.2 Urban background concentrations obtained with the OML model

The OML model has been run for the pollutants $NO_2$, $SO_2$, PM10 and Lead. Based on hourly time series, the OML model is able to compute hourly averages as well as 24 hours, monthly and annual average concentrations for comparison with the EU limit values and assessment thresholds. The limit values, lower and upper assessment theresholds for the various pollutants are previously presented in table 1.

### $NO_2$ – concentration distributions

The figures below present the concentration distribution field on the modelling area for $NO_2$. The exceedence of LAT is visualised with yellow colour, the exceedence of  UAT with orange and LV with red colour.

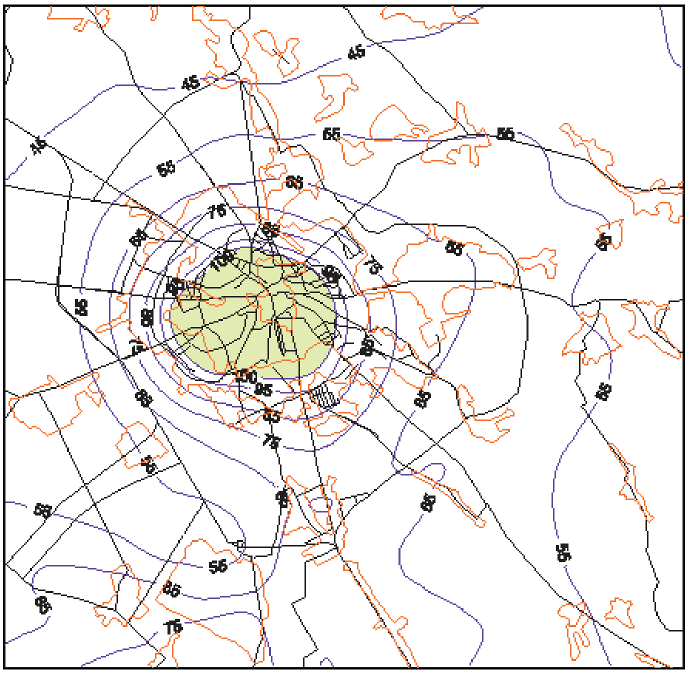

***Figure 18*** Map of 18-th highest hourly values of $NO_2$ in the urban background

It can be seen that the limit value for $NO_2$ (200 μg/m$^3$) has no exceedance for the entire model grid, while the LAT (100 μg/m$^3$) is exceeded in a large area covering the central part of the city. There is no exceedance of the UAT either (140 μg/m$^3$).

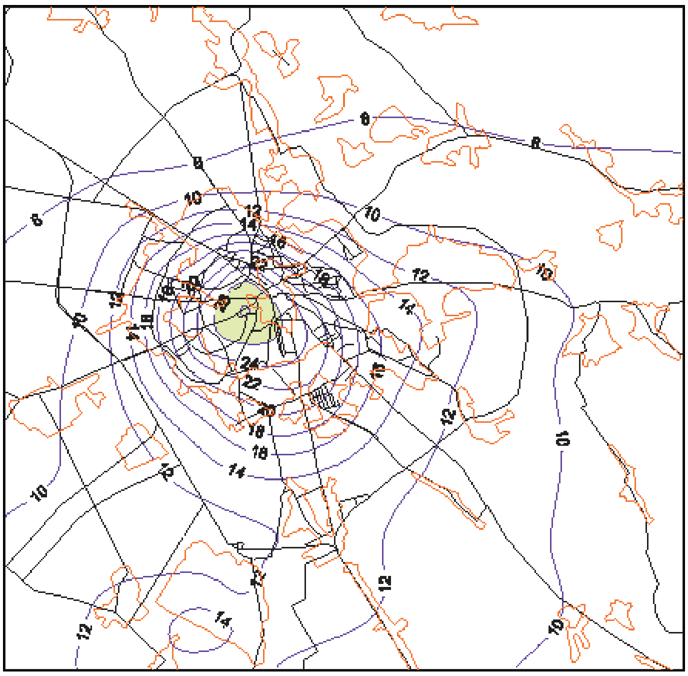

***Figure 19*** Map of annual mean values of $NO_2$ in the urban background

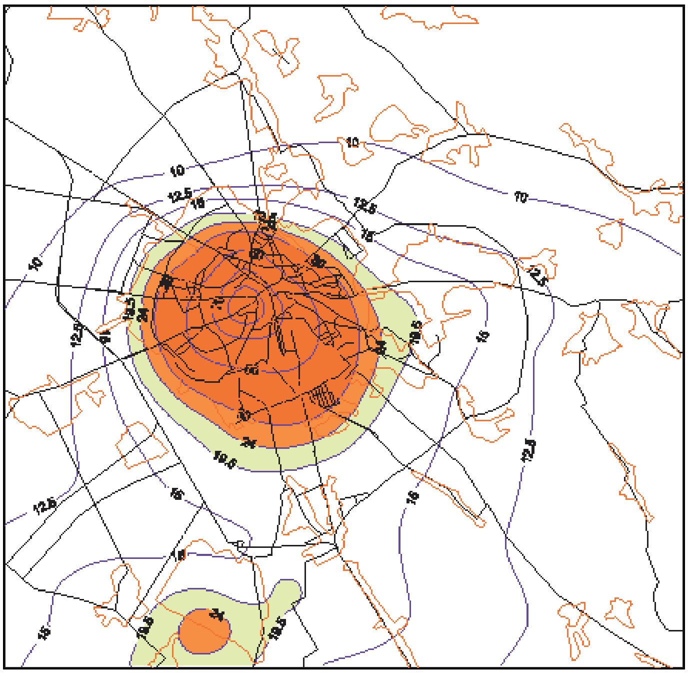

***Figure 20*** Map of annual mean values of $NO_x$ to protect ecosystems

The annual mean value for ecosystem protection (30 µg/m$^3$) is excedeed in a large area covering the central part of the city. The UAT (24 µg/m$^3$) is exceeded in the central part and in a small area in the south part while the exceedence of LAT (19.5 µg/m$^3$) covers larger areas in the central and south part of the model grid.

*$SO_2$ – concentration distributions*

The figures below present the concentration distribution field on the modelling area for $SO_2$. The exceedence of LAT is visualised with yellow colour, the exceedence of UAT with orange and LV with red colour.

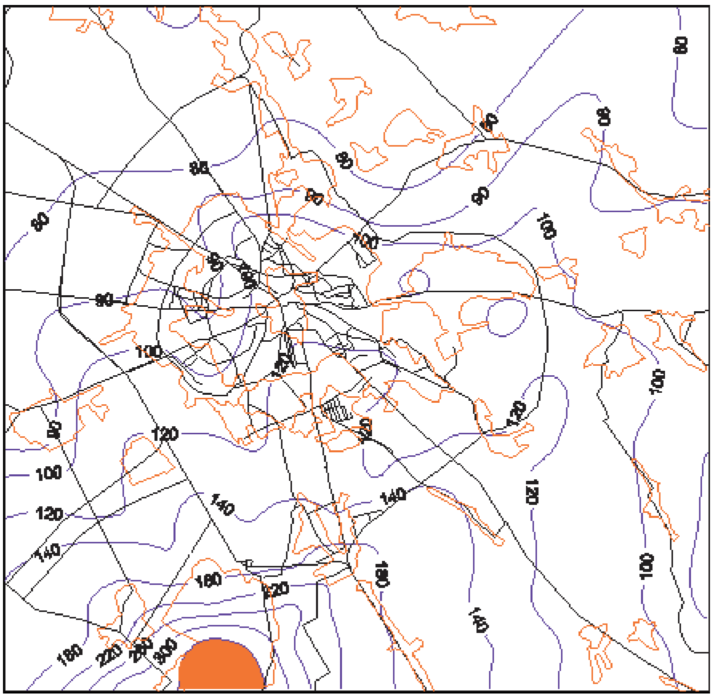

***Figure 21*** Map of 24-th highest hourly values of $SO_2$ in the urban background

One can observe that the hourly limit value for $SO_2$ (350 μg/m$^3$) is exceeded in a limited region on the modelling grid which cover the south area, closed to the Brazi Refinery, one of the main sources of $SO_2$ emission. No LAT and UAT are defined for the 24-th highest values.

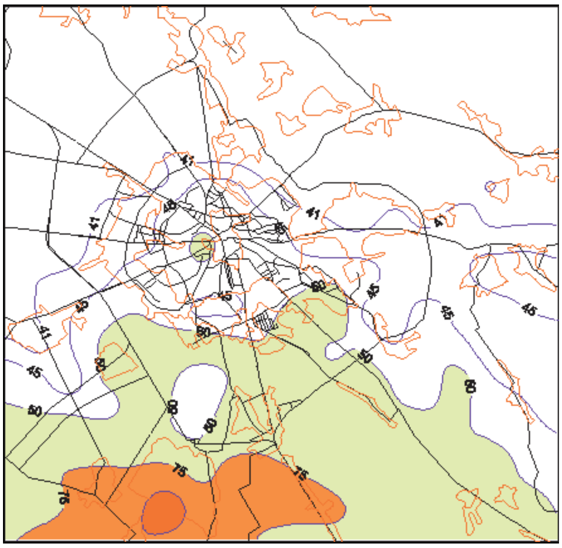

***Figure 22*** Map of 3-rd highest 24 hour values for $SO_2$ in the urban background

One can observe that the 24 hour limit value for $SO_2$ (125 μg/m$^3$) is exceeded in a small area closed to the Brazi Refinery. The UAT (75 μg/m$^3$) and LAT (50 μg/m$^3$) for $SO_2$ is exceeded in a large region on the modelling grid which also covers the southern area. There is also a limited region in the central part of the city where the LAT is exceeded. The UAT is exceeded in the vicinity of Brazi Refinery.

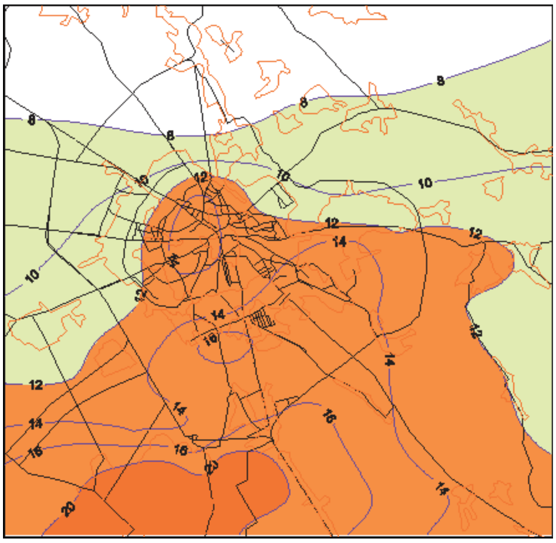

***Figure 23*** Map of annual mean values of $SO_2$ to protect ecosystem

The annual limit value (20 μg/m$^3$) for ecosystem protection is exceeded for $SO_2$ in the south part of the agglomeration. The UAT (12 μg/m$^3$) and LAT (8 μg/m$^3$) are also exceeded in the most part of the modelling grid.

*$PM_{10}$ – concentration distributions*

The figures below present the concentration distribution field on the modelling area for $PM_{10}$.

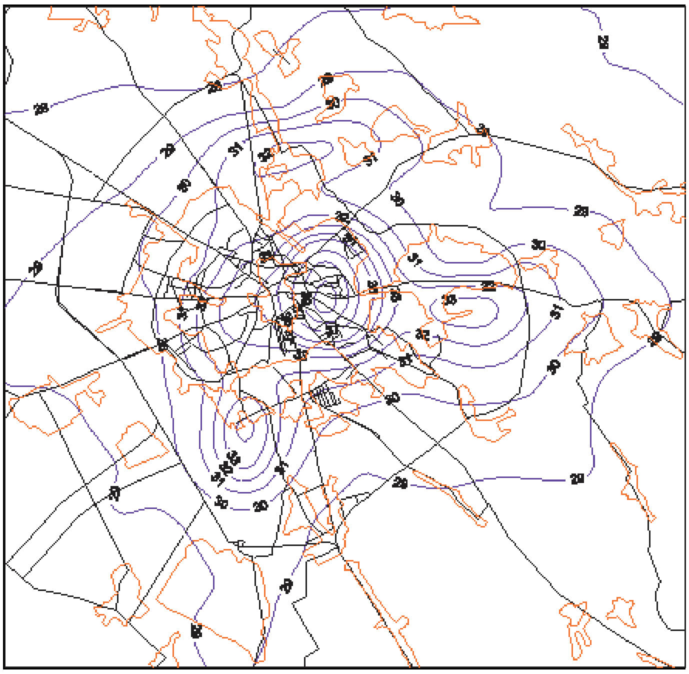

***Figure 24*** Map of 35-th highest 24 hour values of $PM_{10}$ in the urban background

No exceedance of the limit value for $PM_{10}$ (50 µg/m$^3$ in 2005).

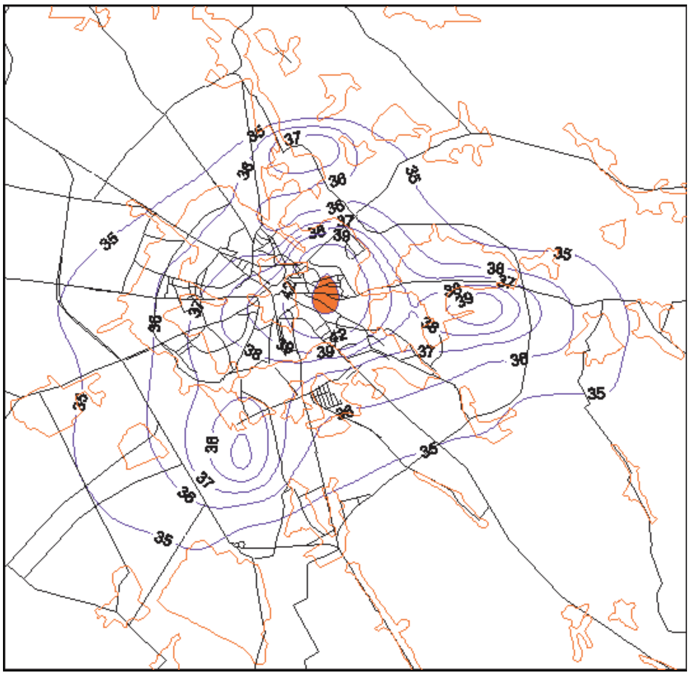

***Figure 25*** Map of 7-th highest 24 hour values of $PM_{10}$ in the urban background

One can observe that LAT (20 µg/m$^3$) and UAT (30 µg/m$^3$) are exceeded all over the modelling area. The limit value in 2010 (50 µg/m$^3$) is exceeded in a small area in the central part of the city.

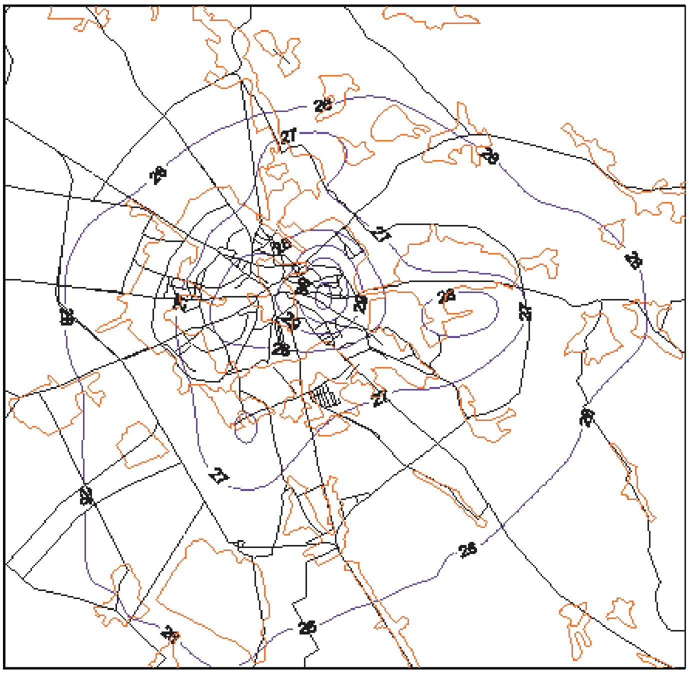

*Figure 26* Map of annual values of $PM_{10}$ in the urban background

The annual limit value for $PM_{10}$ in 2005 (40 µg/m$^3$) is not exceeded on the modelling grid while the LAT (10 µg/m$^3$), UAT(14 µg/m$^3$) and annual limit value in 2010 (20 µg/m$^3$) are exceeded on the entire modelling grid.

*Lead - concentration distributions*

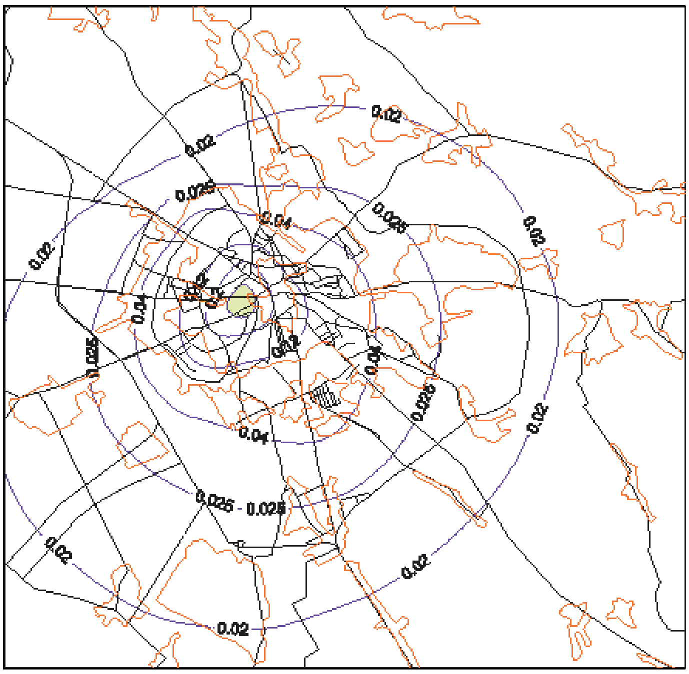

*Figure 27* Map of annual mean values of Lead in the urban background

The annual average (0.5 µg/$m^3$) for Lead is not exceeded. LAT (0.25 µg/$m^3$) is exceeded in a very small area in the central part of the city.

## 4.3 Street concentration obtained by the OSPM model

Input data for the OSPM for the four street canyons are presented in section 4.4. The model can generate the hourly concentration in two receptors positioned at the street level (on both sides of the streets). An example of the street configuration and receptor positions is presented in the figure 5.12.

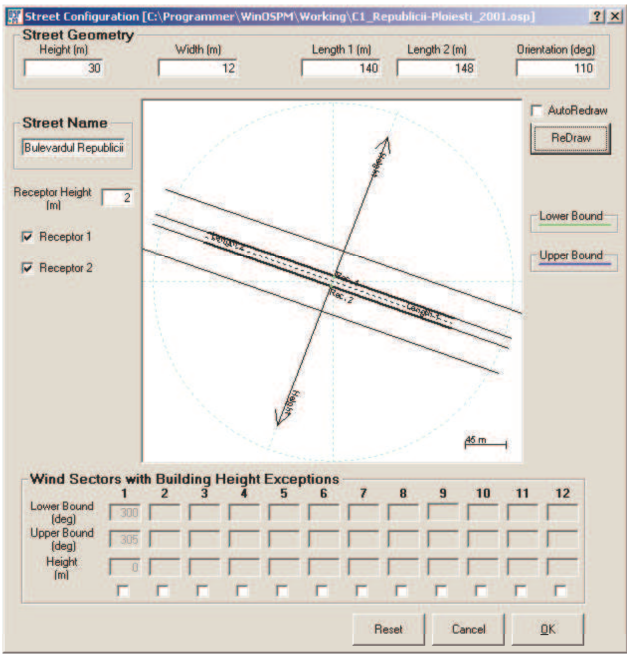


*Figure 28* An example of street configuration (Bulevardul Republici)

The results obtained with the model for the $NO_2$ street level concentration are presented in the table below

**Table 8**. *The $NO_2$ annual and hourly average concentration at the street level*

| Street canion | 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$^3$] |
| Bulevardul Republicii | 54.2 | 143.8 | 49.7 | 144.4 |
| Bulevardul Bucuresti | 51.4 | 140.7 | 50.9 | 138.1 |
| Strada GHE. GR. Cantacuzino | 46.9 | 129.1 | 41.6 | 128.9 |
| Strada Mihai Bravu | 49.2 | 131.2 | 44.2 | 132.8 |
| Limit value | 40 | 200 | 40 | 200 |
| UAT | 32 | 140 | 32 | 140 |
| LAT | 26 | 100 | 26 | 100 |
| Urban background | 10.3 | 68.1 | 10.3 | 68.1 |

The general features of the $NO_2$ concentration field at the street canyon level are the high annual average and hourly concentration which exceed, generally, the annual limit value, hourly LAT and particular the hourly UAT (Bulevardul Republicii and Bulevardul Bucuresti).

The hourly limit value has no exceedance. We believe that the reason for these high concentrations at the street levels is due to the high ADT and the limited width of the streets.

## 4.4 Indicative comparison of model results and EPI measurements in Ploiesti

The Ploiesti EPI performed daily measurements for $NO_2$ and $SO_2$ during 2000 in a number of 6 stations. The OML model has been run in a limited number of receptors which has the same position with the respective monitoring sites. The results (hourly values) have been aggregated on a daily value basis and a crude comparison with the measurements was possible. In the table below we present the comparison of the annual average and the maximum 24 hour value both modelled and measured.

Good correlations for these two indicators have been found at some monitoring sites. One can observe that for $NO_2$, the model underestimates the measurements while for $SO_2$, the model overestimates the measurements.

**Table 9**. *Measurements vs. modelled results at the monitoring sites*

| Station | Type | $NO_2$ [µg/m$^3$] | | | | $SO_2$ [µg/m$^3$] | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Modelled | | Measured | | Modelled | | Measured | |
| | | Average | Maximum | Average | Maximum | Average | Maximum | Average | Maximum |
| ICERP | Traffic | 15 | 44 | 24 | 60 | 11 | 54 | 9 | 23 |
| I.P.M - office | Traffic | 19 | 53 | 24 | 72 | 11 | 53 | 8 | 25 |
| UBEMAR | Urban back-ground | 14 | 49 | - | - | 14 | 57 | 10 | 90 |
| Unit 2 Fire Brigade | Industrial | 20 | 55 | 29 | 82 | 17 | 58 | 9 | 40 |
| Paediatric hospital | Urban back-ground | 25 | 65 | - | - | 13 | 61 | 8 | 35 |
| St. raf. Cor-latesti | Urban back-ground | 16 | 54 | - | - | 15 | 62 | 9 | 27 |

An hourly time series comparison between modelled results and measurements was possible but this showed a week correlation between model and measurements. This might be caused by the daily uncertainties in measurements (representativity of stations, instruments, and methods), the goals of time variation of emission and other lack of information necessary for model input.

## 4.5 Indicative comparison of model results and passive measurements in Ploiesti

Passive sampling campaigns of two weeks for $NO_2$ and $SO_2$ have been performed in the pilot areas to provide an indicative assessment of the quality of the present monitoring network (Mocioaca et al. 2001). The main conclusion from the study indicated that the EPI methods for sampling and analysis of $SO_2$ and $NO_2$ seemed to be better for $NO_2$ than $SO_2$. Comparisons of $NO_2$ concentrations were fair, while it was impossible to compare $SO_2$.

To provide for an indicative comparison of model results, OML model results from the same period and the same locations as where the passive measurements took place have been picked out based on an selection of the appropriate 1*1 km$^2$ grid cell. Comparisons should only been carried out for the locations that correspond to urban background locations since the OML models urban background levels. However, street stations have also been included. The OML model should underestimates concentrations at street stations because the contribution from traffic is accounted in when modelling urban background concentrations.
The OML should underestimate $NO_2$ since traffic is a major source of $NO_x$ emission. For $SO_2$ the OML model should give results close to measurements because traffic is a minor source.

The locations of the passive sampling sites in relation to the OML model grid are shown in Figure 29.

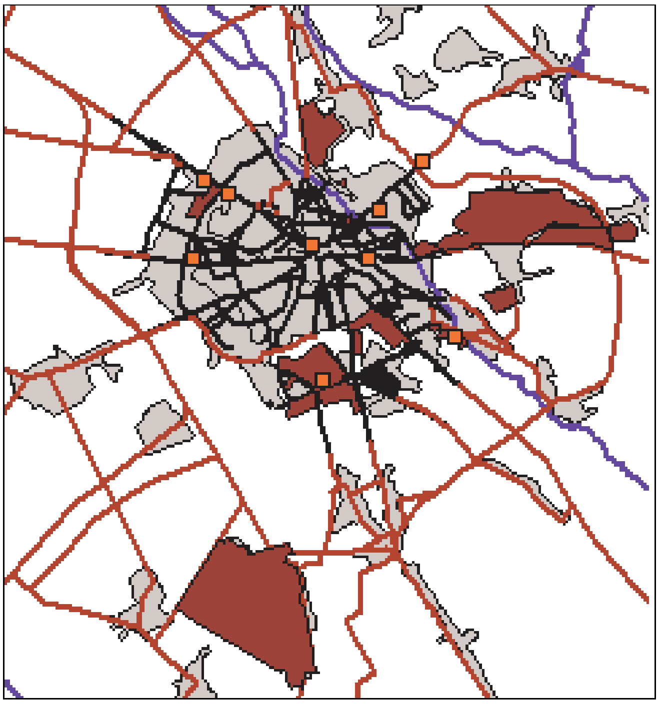

*Figure 29* Locations of the passive sampling sites in relation to the OML model grid

**Table 10**. *Comparison of passive measurements and OML model results for $NO_2$ in Ploiesti*

| Location | Type of station | Date of placing | Date of collection | Time of placing | Time of collection | Measured $NO_2$ [$\mu g/m^3$] | Modelled $NO_2$ [$\mu g/m^3$] |
|---|---|---|---|---|---|---|---|
| ICERP | Traffic | 13.7.01 | 27.7.01 | 8:30 | 9:00 | 17 | 20 |
| RENEL (pay-ments) | Urban background | 13.7.01 | 27.7.01 | 9:00 | 9:30 | 25 | 12 |
| Palatul Culturii | Traffic | 13.7.01 | 27.7.01 | 9:38 | 10:13 | 30 | 20 |
| Poliserv | Urban background | 13.7.01 | 27.7.01 | 10:25 | 11:00 | 13 | 7 |
| I.M.P.-offices | Traffic | 13.7.01 | 27.7.01 | 14:05 | 15:03 | 19 | 13 |

**Table 11** *Comparison of passive measurements and OML model results for $SO_2$ in Ploiesti*

| Location | Type of station | Date of placing | Date of collection | Time of placing | Time of collection | Measured $SO_2$ [µg/m$^3$] | Modelled $SO_2$ [µg/m$^3$] |
|---|---|---|---|---|---|---|---|
| ICERP | Traffic | 13.7.01 | 27.7.01 | 8:30 | 9:00 | 8 | 8 |
| RENEL (payments) | Urban background | 13.7.01 | 27.7.01 | 9:00 | 9:30 | 9 | 10 |
| Palatul Culturii | Traffic | 13.7.01 | 27.7.01 | 9:38 | 10:13 | 6 | 12 |
| Poliserv | Urban background | 13.7.01 | 27.7.01 | 10:25 | 11:00 | 12 | 7 |
| Pediatric Hospital | Urban background | 13.7.01 | 27.7.01 | 11:05 | 11:37 | 12 | 9 |
| St. Raf. Corlatesti | Urban background | 13.7.01 | 27.7.01 | 11:38 | 12:05 | 7 | 11 |
| Unit. 2 Fire Brigade | Industrial | 13.7.01 | 27.7.01 | 12:11 | 13:10 | 7 | 14 |
| Brazi-City Hall | Urban background | 13.7.01 | 27.7.01 | 13:00 | 14:15 | 4 | 17 |
| I.M.P.-offices | Traffic | 13.7.01 | 27.7.01 | 14:05 | 15:03 | 8 | 10 |
| Hospital | Urban background | 13.7.01 | 27.7.01 | 10:10 | 11:05 | 9 | 8 |

*$NO_2$ concentration levels:*

The comparison between model and passive sampler results show that:

- Good correlations at 3 sites
- At two sites the modelled results are two times lowers than measurements
- The both values are bounded approximately by the same limits

We assume that the reason for these uncertainties comes from:

- the inappropriate measurement positions
- the model is averaging the area source emissions while the measurements are locally. For traffic sources the model underestimates the measurements close to the roads. The OSPM model is more appropriate for these comparisons but the lack of representative measurements made them impossible
- Uncertainties in measurements and model inputs.

*$SO_2$ concentration levels*

$SO_2$ concentration levels are in:

- a good correlation is indicated
- significant differences take place at few sites, for example at Brazi, where we believe that the sampler was incorrect installed.

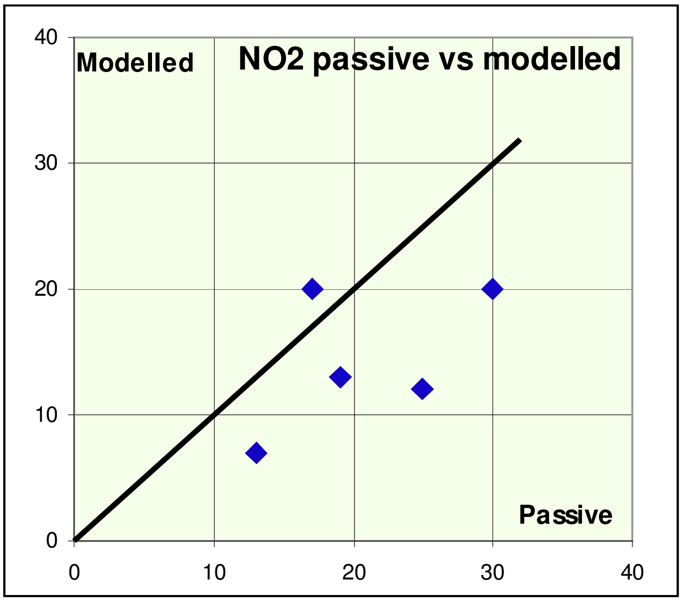


*Figure 30* Comparisions of two-week average $NO_2$ concentrations

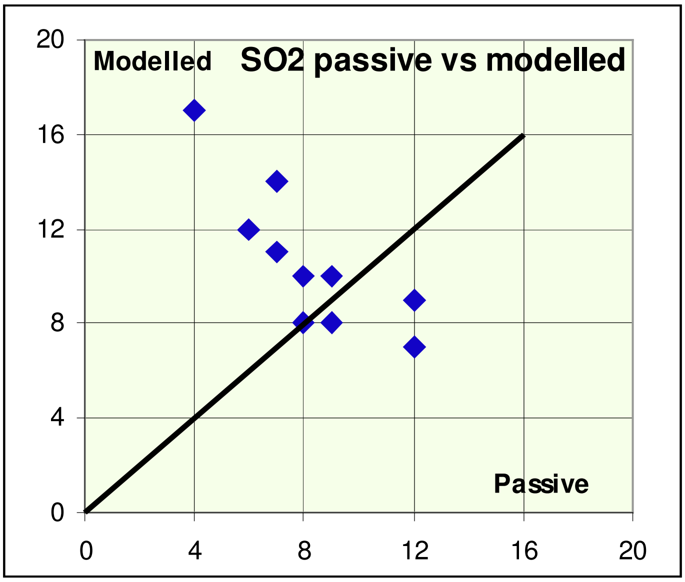


*Figure 31* Comparisons of two-week average $SO_2$ concentrations

## 4.6 Comparison with LAT, UAT and LV

The comparison between the values for urban background concentrations obtained with OML and the limits and assessment thresholds can be summarised in the following table:

*Table 12* Exceedance of LV, UAT, LAT and Romanian AQ limits obtained with the OML model for urban background conditions

| | $NO_2$ | | | | | $SO_2$ | | | | | $PM_{10}$ | | | | | Lead | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | a | b | c | d | e | a | b | c | d | e | a | b | c | d | e | a | b | c | d | e |
| 1-hour limit | | | | | | | | | | | | | | | | | | | | |
| 24-h limit | | | | | | | | | | | | | | | | | | | | |
| annual limit | | | | | | | | | | | | | | | | | | | | |

a = limit value + margin of tolerance
b = EU limit value 2010
c = UAT
d = LAT
e = Romanian limit value

No Exceedance

Exceedance

## 4.7 Input data limitations and uncertainties

### Emission inventories

The main limitations consisted in the lack of necessary information on some stationary industrial point sources and industrial area sources, and of some elements related to road traffic.

***Industrial (point and/or area) sources*** – the information obtained was not sufficiently detailed to allow emission calculation for:

- Secondary processes in crude oil refinery industries
- Handling of feedstock /products in metal processing industries, food industry and small industrial companies

***Urban (area) sources*** – information could not be obtained on:

- Construction/demolition activities
- Consumption and characteristics of liquid and solid fuels used for residential heating in the 2000 individual houses in Bereasca and Colonia Astra

For the latter category of sources, consumption assessment was based on the number and size of the housing units. In regard to fuel characteristics, the general information available was taken into consideration.
As this source category is minor compared to the other area sources, the resulting uncertainty is insignificant.

Note that the emission inventory covers in full:

- Combustion processes in industrial and urban sources
- Major and medium sources related to industrial processes (other than combustion)

Total emissions of $SO_2$, NOx, $PM_{10}$ generated by stationary (point and area) sources are underestimated by about 5%.

Other limitations derive from the missing detailed information on the operating regimes of sources, especially industrial sources. This creates uncertainties that are hard to assess, in the temporal variations associated to different categories of sources and, hence, in the series of modelled hourly and daily concentrations.

Note also that it was impossible to get sufficiently detailed technical information on the industrial equipment and technologies, which generates some uncertainty related to emission factors and to emission calculation, respectively. Considering that the most important sources still work with obsolete equipment and technologies, we adopted in principle the oldest values of emission factors associated to the respective activirties.

An important element that has to be emphasised was the lack of emission measurements.

**Road traffic**

The main limitations consist of lack of specific information required by the COPERT software in calculating emissions and of models to determine concentration fields, i.e.:

- Structure of the vehicle fleet in the Ploiesti agglomeration
- Cold starts
- Time variation of traffic intensity as an area source

Note that the national databases related to road traffic contain only few of the elements required by the COPERT software. Also, there are very few traffic studies that were or are being developed for different cities.

It is appreciated that the uncertainty in determining emissions generated by road traffic as an area source is about 20%.

**Meteorological data**

The main general limitations relate to the lack of input data in accordance with the modelling requirements.

In particular, limitations relate to the input data for the meteorological pre-processor software:

- Lack of automatic, high sensitivity equipment, for accurate real-time measurement of classical met parameters at the synoptic (ground) stations. The main problem is wind, determined by visual (discontinuous) observation at the weathervane, which has a major impact on the quantity and quality of necessary data.
- Lack of ground-level solar radiation measurements and of specific measurements on the boundary layer. For Ploiesti, we needed to extrapolate radio-probe data from Bucharest.

We needed to generate data to cover the gaps, which inherently determined uncertainties, difficult to assess in regard to model input data sets.

**Data on regional background pollution**

Since the national regional background pollution monitoring network (regio'nal and base stations in the EMEP network) operating in the 80s was decommissioned, we had to extrapolate the (hourly) data for ozone, (daily) data for sulphur dioxide and nitrogen dioxide measured in Hungary (in the EMEP network) and to generate hourly datasets for $NO_2$ and $SO_2$ based on the EMEP data.

As the Romanian territory is subject to the influence of remote pollutant emissions not only from the west, but also from the north, north-east, south and south-west, uncertainties may exist in the background pollution level we used.

# 5 Conclusions

## 5.1 Conclusions of air quality assessment in accordance with the EU Directives in the agglomeration of Ploiesti

A methodology has been demonstrated for how to carry out a preliminary assessment based on air quality modelling. Ploiesti has served as a case study. Air quality modelling is highly depending on high quality input data and the possibility to check model results against high quality measurement data to assess the input data quality.

In the present case study we were only able to make an indicative comparison of modelled and measured data for NO2 and SO2 based on some monitoring stations and a passive measurement campaign. For mean values the correlation was fair and most modelled results were within a factor of two of measured results.

A more complete comparison would require high quality monitoring data that is not available at present and it is therefore difficult to assess the uncertainty in modelled results.

The following air quality assessment in relation to limit values and thresholds are therefore also indicative.

***Pollution by $NO_2$***

- Urban background level:
  - Average annual and 18-th highest hourly concentrations below LV and UAT
  - Average annual and 18–th highest hourly concentrations above the LAT

- Street canyons:
  - 18-th highest hourly concentrations below LV
  - 18-th highest hourly concentrations above LAT and UAT
  - Average annual concentrations above LV, but below LV+MT

Thus, at the urban background level, **$NO_2$** pollution ranges in the 2$^{nd}$ assessment regime (between LAT and UAT), while in street canyons they range in the 1$^{st}$ assessment regime (above UAT, including non-compliance with LV).

Traffic orientated measurements need to be taken in accordance with the EU Directive requirements.
Air quality assessment will necessarily have to be based primarily on the results of measurements, combined with modelling results.

*Pollution by $SO_2$*

- Urban background level:
  - 24-th highest hourly, 3-rd highest daily average, and mean annual concentrations (ecosystem protection) above LV, but below LV+MT
  - 3–rd highest daily average and annual average concentrations above LAT and UAT

Therefore, **$SO_2$** pollution ranges in the 1st assessment regime (above UAT, including non-compliance with LV). Measurements in accordance with the EU Directive requirements will be needed as a main basis for AQ assessment.

*Pollution by $PM_{10}$*

- Urban level:
  - 35-th highest daily average and annual average concentrations below LV (2005)
  - 7-th highest daily average concentrations above LAT and UAT
  - Average annual concentrations above LAT and UAT
  - 7-th highest daily average and annual average concentrations above LV (2010).

Thus, although pollution by **$PM_{10}$** is in compliance with LV (2005), it ranges in the 1st assessment regime. For the second phase, 2010 there is no compliance. Measurements are needed as a main basis for AQ assessment.

*Pollution by Pb*

- Urban level:
  - Average annual concentrations below LV and UAT
  - Average annual concentrations above LAT

Thus, **Pb** pollution complies with the LV. Levels range in the 2nd assessment regime. Measurement results are necessary in combination with modelling, to underlie AQ assessment.

## 5.2 General conclusions

**AQ modelling has the following benefits:**

- It is a very efficient AQ assessment and management tool for an agglomeration /zone
- Allows mapping of distributions and spatial and time of concentrations at various geographical scales
- Allows the assessment of various source contributions to air pollution
- Allows AQ assessment for past periods of time, and AQ forecasting based on emission reduction, urban and/or industrial development, or land use scenarios.
- Allows assessment at very much lower costs than those of measurements.

**AQ modelling also involves the following disadvantages:**

- Needs to obtain and use very high quality input data (emission inventories and specific met data, regional background pollution levels)
- The main requirements for input data relate to the necessary quantity and quality of emission data and meteorological data. The use of correct and complete data in emission inventories and met data are the most important assumption in obtaining accurate assessment results.
- Model results are less accurate than measurements, but only if measurements use adequate equipment, data quality control and representative locations.
- Models are working tools that depend on the level of knowledge at a given time, and can only reflect existing knowledge.

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This report describes the preliminary assessment of the air quality in Ploiesti agglomeration in Romania based on AQ modelling. The methodology described serves as a role model for future assessments in Romania where Ploiesti has been chosen as a pilot study. The report is the first of its kind in Romania since it is the first time that comprehensive AQ modelling has been applied for assessment. The preliminary assessment is carried out in accordance with the requirements in the EU directives on air quality assessment and management. The four pollutants listed in the first EU daughter directive are covered: $NO_2$, $SO_2$, PM10 and lead. Modelling is based on the Danish models OML for urban background modelling and OSPM for street canyon modelling. Modelled concentrations are also compared with an indicative passive measurement campaign. Modelled and measured concentrations are compared to EU thresholds and limit values.

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