AIR POLLUTION MODELING IN THE BULGARIAN-GERMAN TWINNING PROJECT "SUPPORT OF AIR QUALITY MANAGEMENT AT LOCAL LEVEL"

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INTRODUCTION

By the project "Support of Air Quality Management at Local Level (BG99EN02)" the EU supports under the management of the Bulgarian and German Ministries of Environment the analysis and the assessment of the air pollutant concentrations in Bulgaria. Aim of the project is to support the Bulgarian administrations in the implementation of the Ambient Air Quality Framework Directive and the corresponding 1st Daughter Directive (SO2,NO2,PM10, Lead). For the execution of that task, a user friendly dispersion model was looked for, being able to cope with the usual groups of sources as streets, stacks, domestic heating etc. and additionally being able to digitize and display the input data on the basis of maps. The German partner looked for that in Germany and finally decided to use the modeling system SELMA^{GIS} (SFI GmbH, 2000), which is in daily operational use at Lohmeyer Consulting Engineers and commercially available via SFI GmbH Software für Immissionsberechnungen, Karlsruhe. SELMA^{GIS} was chosen because the user friendly interface, the comparatively low level of requirements for the meteo and emission input data and the special features for treatment of PM10 sources from vehicle traffic fits well in the project scope and was compatible with the input data which could be made available.

The model should help to explain the present air pollution concentrations, to analyze the causes of these concentrations and to estimate the effects of emission reductions.

THE MODELING SYSTEM SELMA^{GIS}

The SELMA^{GIS} modeling system (System for Calculation and Representation of Air Pollutant Concentrations) is an air pollutant dispersion modeling and handling system. It is able to provide the concentrations and the statistical parameters, needed for example for the comparison to the limit values, set by Directive 1999/30/EG. For improved handling of the data SELMA^{GIS} contains digitizing and display modules, based on the Geographical Information System ArcView (V 3.2a). The system accesses under its surface modules of the following models, see Figure 1:

- DIGIstreet, for digitalizing complex street networks incl. allocation of traffic parameters,
- EMIstreet, for calculating the air pollutant emissions of these streets. It makes use of the exhaust pipe emission factors, determined for Bulgaria by RWTÜV Fahrzeug GmbH (2001). It additionally includes the PM10 emissions caused by dust re-suspension and abrasion of tires, vehicle components and the wear of the street surface as described by Düring et al. (2002),
- DIGIpoint, for the creation of the receptor points,

- PROKAS_V (Gaussian plume model) for the calculation of the additional street concentrations and PROKAS_B (MISKAM-based dispersion library) for calculating the additional street concentrations in built up streets,
- TALBO (at that time the official German regulatory Gaussian plume model) incl. DIGItalbo, for digitalizing the parameters of point and area sources, as well as for calculation of the additional concentrations caused by emissions from these sources,
- DIGIsum, for calculation of the total pollution on the basis of each individual calculated additional concentration and the background concentration. It also contains a NO/NO2 conversion module and modules to calculate the statistical parameters of the concentrations, needed for an assessment under the EU Air Quality Directives.
- System requirements for SELMA^{GIS} are a Windows 98 or 2000. A Pentium III processor and a minimum of 128 RAM are recommended.

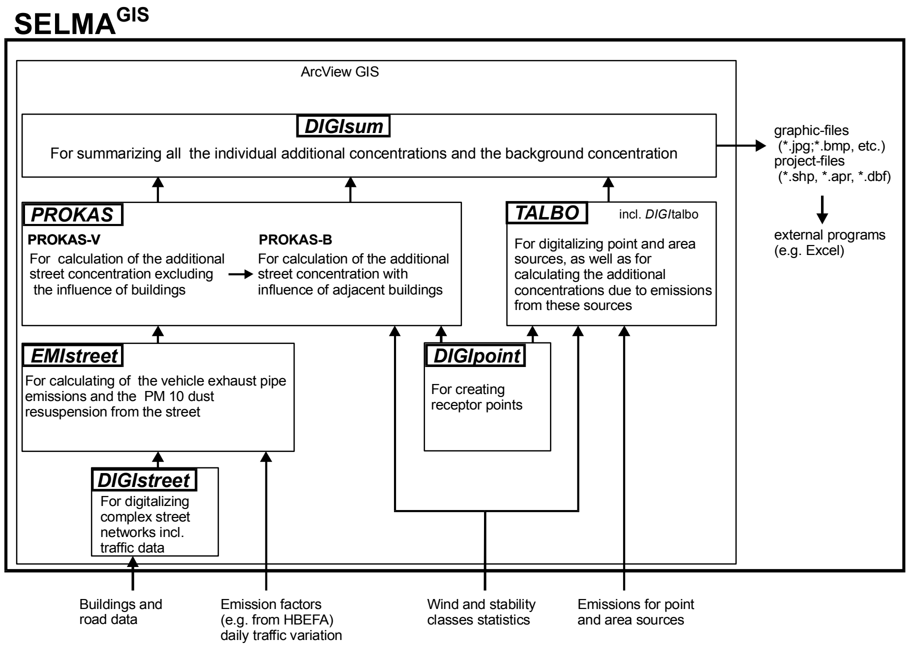

Figure 1. SELMA^{GIS} Model Diagram.

APPLICATION IN BULGARIA

General Information about the project

In a first step, the city of Pernik (ca. 30 km west of Sofia) was chosen for a pilot study. An air pollutant-monitoring program was executed for PM10, SO2, NO2 and lead. This includes measurements by an automatic station at a fixed location (Dimova Mahala), as well as gravimetric PM10 measurements over 6 to 12 months at several manual stations and measurements at several other locations by a mobile station. The locations were chosen to cover the influence of the major local sources from stack emissions to domestic heating and traffic as well as the local background concentration. See Figure 2.

The analysis of the results of the measurements led to the conclusion that the limit values for PM10 are significantly exceeded reaching annual mean values of 60 to 70µg/m^3, whereas the limit values for SO2, NO2 and lead were kept in 2001. The annual mean concentrations found are higher than in Western Europe, but comparable to other hot spots in Bulgaria (e.g. Sofia) and other cities in Middle and Eastern Europe.

The analysis of the reasons of exceedance for PM10 based on the measurement data alone did not provide clear conclusions. But with the help of the dispersion modeling an estimation of the share of the different emission sources and the regional background concentration for the local ambient air quality situation was possible.

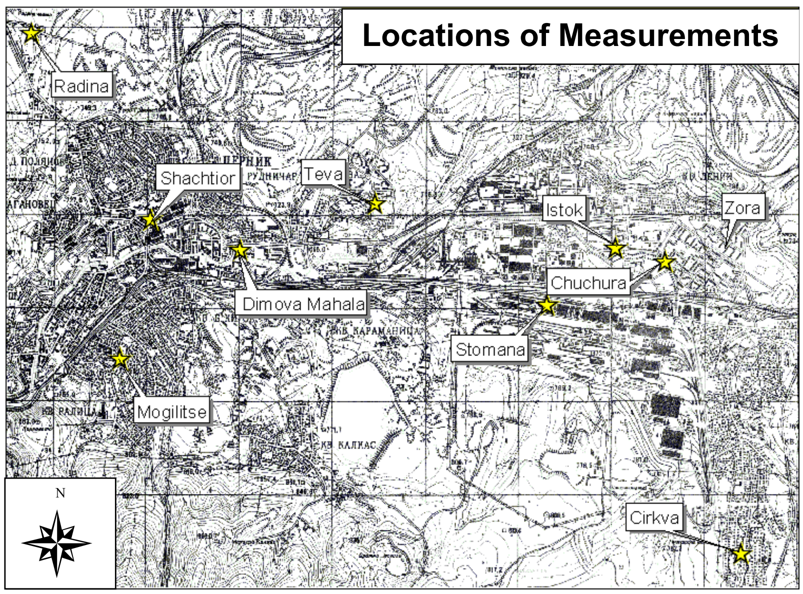

Figure 2. Pernik: Location of measurements.

Calculations

The dispersion calculation was done including the emissions of traffic on the main roads, domestic heating, stack and fugitive emissions from industrial plants and dust emissions from local ash and waste deposits.

For use for the emission modeling, traffic counts were executed and for the dispersion calculation meteorological measurements were done. The domestic heating emission factors were derived from factors used in Germany and other countries and taking into account the special characteristics of the fuel used locally. The emission factors of the dust emissions from area sources like ash and waste deposits were derived from factors and formulas published by US-EPA and a VDI guideline.

The calculations were done for a fixed 250 m x 250 m grid in the inhabited area of the city and increased to a 500 m x 500 m grid in the vicinity plus all locations of the field measurements. The calculation was done for the contributions of the different sources, additionally the total concentration as sum of these contributions plus the regional background concentration was determined.

Comparison Modeling/Monitoring for PM10

The table below shows as an example the comparison between the results of modeling and monitoring for PM10 (gravimetrically determined) at the monitoring sites. Only the first four locations have a sufficient number of samples to allow for the estimation of an annual mean value. Modeling and monitoring seem to fit astonishingly well for these four locations. The other locations with significant lower number of measurements are included for information only.

Conclusions for Pernik

With the help of the dispersion modeling a detailed analysis of the share of the different sources and the regional background concentration for the local ambient air quality quality was possible. Additionally the modeling showed that the concentrations of SO2 and NO2 are in a range where exceedances of the limit values cannot be excluded for sure. At the monitoring sites there were no exceedances, but as only one site covers the required measurement period of one year for these pollutants it can not be ruled out that this monitoring might not have taken place at the location where the highest concentrations occur.

Table 1. Comparison results measurements/modeling for PM10. Mean values in µg/m^3. Regional background concentration adapted for minimum difference modeling/measurements.

Location	Modeling	Measurements	No. samples
Istok	57.8	62.4	226
Cirkva	53.9	54.8	214
Dimaha	66.0	66.0	123
Stomana	57.8	59.9	125
Mogilitshe	67	60.7	29
Shachtior	57	76.6	23
Radina	37.6	46.3	15
Chuchura	54.7	51.2	45
Teva	55.5	67.7	26

The ambient air quality (AAQ) for NO2 is mostly influenced by the road emissions. The highest values were found near streets with high traffic and a high share of heavy-duty vehicles. The AAQ situation for SO2 is strongly influenced by domestic heating and by emissions of the local district heating plant (DHP). The concentrations for lead are dominated by traffic emissions (leaded fuel) and emissions of the local steel plant.

The AAQ situation for PM10 is most complex and determined by several sources in the city as well as by the regional background concentration. All these sources contribute to the exceedance of the limit values. The highest contribution for the locally caused PM10 concentrations seems to be due to domestic heating. The DHP, the steel work, the vehicle traffic and the erosion from dusty areas including ash deposits also contribute significantly to the PM10 concentration, but to a different degree in the different areas of the city.

Another main result of the modeling was the conclusion that a high regional background concentration of PM10 significantly contributes to the PM10 concentrations in Pernik. This regional concentration is considered to be caused as well by regional anthropogenic sources (from e.g. nearby cities like Sofia, Bobov Dol etc.) as by regional natural sources like erosion of open soil and by national and transboundary pollution of anthropogenic and natural origin. The high background concentration is additionally due to the low precipitation in 2001. This reduced the wash out and led to increased dust emissions from the ground.

According to the results of the dispersion modeling the share of the background concentration in the total pollutant concentration measured is about 50% and more, depending on the location. This regional background concentration is in the magnitude of 30 to 35 µg/m^3 (annual mean) thus already close to the limit value. Therefore, actions for reducing the local PM10 emissions are very important, but will probably not be sufficient to reach the limit values.

FUTURE PROSPECTS

The twinning project ended in September 2002. SELMA^{GIS} helped to make it a success and to improve the knowledge about the levels of the air pollutant concentrations and their causes. The Bulgarian authorities plan to go on with the implementation of an air quality management system, aiming on the development of emission reduction strategies.

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