IMPACT OF METALLURGICAL INDUSTRY ON AIR QUALITY IN THE MORAVIAN-SILESIAN REGION

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Abstracts

The particulate matter (PM$_{10}$) air pollution is in the Czech Republic a significant problem, mainly in the highly industrialized Moravian-Silesian Region. The goal of the article is to present analysis of metallurgical industry contribution to annual average PM$_{10}$ concentrations in this region.

The analysis is based on means of the air pollution modelling in accord with the Czech reference methodology SYMOS’97. All relevant PM$_{10}$ pollution sources are included – industrial sources (with special attention to metallurgical industry), domestic boilers and the road traffic. Also the local pollution background and the frontier transmission are estimated. Annual average PM$_{10}$ concentrations were modelled for each group of pollution sources and for the total pollution situation. Emission and meteorological data is valuable for year 2006.

The modelling results showed that the annual limit value for PM$_{10}$ was in 2006 exceeded at the majority of populated areas of the Moravian-Silesian Region. The highest concentrations were achieved in zones buffering large settlements, where effects of industry, high traffic and local heating are combined. According to the modelling and analysis results the important part of PM$_{10}$ pollution in areas of the region where long term limits were exceeded was in 2006 caused by industrial sources.

Key words: air quality, modelling, metallurgy, impact, pollution source

1 PREFACE

The particulate matter (PM$_{10}$) air pollution is in the Czech Republic a significant problem, mainly in the highly industrialized Moravian-Silesian Region and Ostrava city. According to the Statistical Environmental Yearbook of the Czech Republic 2007 [1] the region recorded the highest values for pollution by the PM$_{10}$ fraction.

The pollution situation in this region is complicated due to a long term tradition of heavy industry, dense population and geomorphological condition which correspond to particular meteorology. See Fig. 1.

Facilities of ArcelorMittal Ostrava (coke plant, blast furnaces, tandem furnaces, medium section rolling mill, heavy section rolling mill, wire-rod mill), OKK Koksovny (coke plant), EVRAZ VÍTKOVICE STEEL (steel plant, rolling mills), Třinecké železáry (coke plant, blast furnaces, steel plant), ŽDB Bohumín (foundry, wireworks) reside in the densely populated valley at the area of about 100 km$^2$.

Regional PM$_{10}$ emission balance in 2006 shows that industrial sources form an important part of the emission load [2]. See Table 1.

Table 1 PM$_{10}$ emission balance in 2006

<table>
<thead>
<tr>
<th>Industrial sources total</th>
<th>Primary metallurgy</th>
<th>Local heating</th>
<th>Road transport</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>[t/y]</td>
<td>[%]</td>
<td>[t/y]</td>
<td>[%]</td>
<td>[t/y]</td>
</tr>
<tr>
<td>3945,1</td>
<td>32</td>
<td>1847,0</td>
<td>68</td>
<td>745,6</td>
</tr>
</tbody>
</table>
GEOMORPHOLOGICAL SITUATION IN MODELLLED AREA

Fig. 1 Map composition of geomorphological situation

To manage air quality in the region and apply effective remedies, a detail analysis of emission – pollution relation was made. This analysis was based on air pollution dispersion modelling. The authors have developed their own modelling system ADMoSS to process detailed modelling in vast areas with a huge amount of sources which has been already used to work out many similar studies and analysis and serve to local governments as a decision support tool.

2 METHODS

To assess the emission – pollution dependence the ADMoSS system is used. The system utilizes GIS software to prepare all necessary input data for modelling, divide modelling task into a number of simpler ones, and run the modelling tasks on a parallel supercomputer cluster. It also manages calculations, does data management and result post processing. The final results are presented in a form of GIS created cartographic outputs.

This modelling was performed in accordance with the Czech reference methodology SYMOS’97 (Bubník, 1998) [3]. This methodology is based on the application of the statistical theory of turbulent diffusion formulated by Sutton. It is a Gaussian long-term model. Meteorological data enter the model after processing of real meteorological observations as a weather-type classification, which is determined by the range of wind speeds and the average vertical temperature gradient in the mixing layer. The annual average data on the sources and annual average meteorological data is used. The result is so the annual average concentration of pollutants.

Results of modelling are adjusted in accordance with the pollution monitoring data. The output of the system is a realistic characterization of the pollution distribution which allows analysis of influence of different pollution sources on the air quality.
Analysis comprises a number of basic steps. First of all there is the processing of input data, contenting the relevant data about air pollution sources for year 2006, and then the modelling and analysis are run.

2.1 Input data processing

Industrial air pollution sources data are procured from the Register of Emissions and Air Pollution Sources (REAPS). This national database is kept systematically since 1980 and operated by the Czech Hydrometeorological Institute (CHMI). Air pollution sources data are recorded in REAPS in accordance with valid Czech legislation, as amended. There are three categories of stationary emission sources according to their heat output or environmental impact:

- Extra-large and large air pollution sources (REAPS 1),
- Medium-sized air pollution sources (REAPS 2),
- Small air pollution sources (REAPS 3);

And one category of mobile sources – mobile emission sources (REAPS 4).

The individual databases REAPS systems differ not only in their type and number of sources, but especially in the methods of collecting and obtaining data. The updating of annual emission data for industrial point sources (extra-large and large and medium-sized pollution sources) is carried out based on information from the summary operational inventory submitted by source operators of extra-large and large sources to the Czech Environmental Inspection (CEI) and by source operators of medium-sized sources to the basic administrative units with extended jurisdiction. Updating of planar and linear monitored sources (small and mobile emission sources) is carried out on the basis of comparative annual trends in the pertinent social-economic indicators.

From these databases are procured emission characteristic and technical parameters of stationary industrial sources – extra-large and large air pollution sources (REAPS 1) and medium-sized air pollution sources (REAPS 2). This data contains also technological description of air pollution sources. This is very important for divergence assessment during the primary data processing and subsequently modelling (unexpected pollution extremes and identification of emission sources data errors).

Information about emission data sources from REAPS databases does not content the sufficient spatial specification. In fact smokestack or flues of sources can be situated in hundreds or even thousands meters distances. For utilization in this analysis these sources are exactly localized and kept in form of point layer of ESRI shapefile. The shapefile contains emission characteristic and technical parameters of each source which are subsequently used as input modelling data.

Non-industrial air pollution sources can be divided to local heating systems and road traffic. Local heating system is an energetic source appointed for local heating of housing room (houses, apartments etc.). It is important emission source group because of its huge amount, localization in housing development, relatively low chimneys, heat outputs, fuel quality etc. Local heating system keepers have no incumbency to submit the sort and consumption of fuels. Official data source about local heating systems is information from Population and Housing Census (PHC) of Czech statistical office (CZSO). The most up to date PHC is from 2001, so it is necessary to actualized them according to local questionnaires.

Because of the impact importance of local heating systems our institute has developed a special methodology to analyse their distribution in development and to represent them by the network of planar sources. Local heating systems are for the modelling represented by the regular network of planar sources with 100 m cell size. Then emissions are allocated to such represented planar sources. Local heating systems emission calculation is processed in accordance with methodology of Czech Hydrometeorological Institute which is based on the heat inventory (Machálek, 2007).

The road traffic is also one of the important sources. To specify emissions of this category of air pollution sources is difficult. It is based on traffic structure and frequency data assessment. The traffic structure and frequency data are procured from the Road Traffic Census which is operated by Road and Motorway...
Directorate of the Czech Republic. The road traffic is represented by network of linear sources which copy the road network. The parts of lines represent air pollution sources. The optimal length of parts was tested and was set up to 50 m.

Road traffic emissions depend on technical parameters of vehicle, on type of fuel, on type and state of road, on ride mode, on traffic frequency etc. Road traffic emissions are defined in according to emission factors. Emission factors values are procured from MEFA program, v. 06 (ATEM, DINPROJEKT, VSCHT Prague). This way calculated emissions are allocated to the linear sources network and are subsequently used as modelling input data.

2.2 Modelling and Analysis

The next step after input data processing is detailed air pollution modelling. For detailed modelling apart from exactly localized air pollution sources data, the dense network of calculating points (receptors) is necessary. For modelling the area of the Moravian Silesian region is divided by the graticule with 1500 m cell size. For extra-large and large air pollution sources which impact by their emission vast areas, the receptor graticule with 100 m cell size is used. For lower sources with closer impact (medium-sized sources, local heating systems and road traffic) the special compounded graticule is used. Such graticule consists of two parts. The first one is the 2500 m buffer of medium-sized sources, respectively 1500 m buffer of local heating system and road traffic. These buffers consist of the 100 m receptor graticules. The second one contains the rest of modelled area and consists of the 1500 m receptor graticule. By this way it is possible to obtain detailed pollution data in areas where they sharply fluctuate and in the same time control the pollution in the whole area.

By means of GIS modelling task are divide into a number of simpler ones according to the described graticule and run at the parallel supercomputer cluster. Results are presented in the form of GIS created cartographic outputs.

Modelling is followed by the modelling results assessment and analysis. The participation of industrial sources, primary and secondary metallurgy is assessed. Then the preponderance of these groups of sources is analysed. Each analysis is run in GIS.

3 RESULTS

According to the modelling results the annual limit value for PM$_{10}$ (40 µg/m$^3$) was exceeded in 2006 at the majority of populated areas of the region. For concentration distribution filed see Fig. 2 bellow.

The highest concentrations were achieved in areas of large settlements where effects of industry, high traffic and local heating are combined. It concerns the city of Ostrava, Opava, Bohumín, Karvina, Trinec, Frydek – Mistek, Studénka. Maximum value occurs in the city of Ostrava, Bohumín and Třinec where the concentration exceeds 60 µg/m$^3$ and also where the facilities of primary metallurgy (Ostrava and Třinec) and secondary metallurgy (Bohumín) are situated.

The modelling of contribution of primary metallurgy facilities to pollution situation in 2006 shows that this group of sources by itself is able to cause excess of the annual PM$_{10}$ limit value in areas close to ArcelorMittal Ostrava (coke plant, blast furnaces, tandem furnaces), OKK Koksovny (coke plants), EVRAZ VÍTKOVICE STEEL (steel plant, rolling mills), Třinecké železáry (coke plant, blast furnaces, steel plant). See the left map composition in Fig. 3 bellow. In accord with modelling result the contribution of primary metallurgy facilities to the pollution situation in 2006 locally quite important. This fact confirms the analysis of preponderance of this group of pollution sources which shows where primary metallurgy sources dominate the other groups of pollution sources (the rest of industry together with local heating systems and transport). See the right map composition in Fig. 3 (the red colour marks the area where the primary metallurgy effect preponderates; the yellow marks the area where the impact of primary metallurgy is comparable to other groups of sources).
4 DISCUSSION

The modelling of the particulate matter pollution distribution in the Moravian Silesian region showed that the air quality is impaired due to the combined effect of industrial sources, road traffic and local heating systems. The results of air quality analysis indicated that the industrial sources and especially primary metallurgy effected in 2006 the pollution situation in the important way. Together with adverse meteorological conditions it causes locally concentration levels exceeding limits and contributes to increment of particulate matter background in the major part of modelled area.
The analysis of the situation in 2006 indicates that the air quality improvement in the region to the level corresponding to the annual limit value is implicated also by further reduction of industrial sources emissions as was also concluded in other studies [5].

It is necessary to admit that nowadays the part of assessed primary metallurgy technologies in the region has been or will be modernize, substituted or arranged and has accepted more strict emission standards also on the base of the processed study [2].

5 CONCLUSION

The modelling of the PM$_{10}$ pollution distribution in the Moravian Silesian region showed that the annual average concentration exceeds the limit value in the important part of the populated area. The air quality is impaired due to the combined effect of industrial sources, road traffic and local heating systems.

Results indicate the significant impact of industrial sources and especially close to the metallurgical facilities. Local concentration levels caused by metallurgical facilities are according to the modelling in 2006 exceeding limits and contribute to the increment of particulate matter background in the major part of modelled area.

To improve the air quality in the region to the level corresponding to the annual limit value is necessary in accord with modelling to reduce industrial sources emissions. But also other remedies concerning the local heating systems and the transport are demanded.

Nowadays condition of the metallurgical facilities in the region has improved. A lot of them has been or will be modernize, substituted or arranged and has accepted more strict emission standards. But it does not concern all of them and it is necessary to continue this positive trend. The metallurgy has in the region a long term tradition and to have modern, top-of-the-range technologies in not only the question of environmental impact.

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REFERENCES


