A SCREENING MODEL TO ASSESS AIR QUALITY IN THE VICINITY OF CAR PARKS

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ABSTRACT

In respect to most traffic induced pollutants, air quality in urban areas is getting better. But problems still may occur near relevant sources, e.g. beside heavily used traffic lines, in street canyons or near a concentrated pollutant source, such as the exhaust air outlet of a car park. While the pollutant release inside a car park can be calculated easily on the basis of only a few necessary input data (Zenger, 1998), dispersion in urban areas can only be estimated with complex numerical dispersion models which are complicated to handle and therefore can not routinely be used. For this reason, a screening model was developed to assess atmospheric dispersion near exhaust air outlets of car parks. The model is presented here. As an example, the emission due to ventilation of a medium size car park is examined. Results show that in the neighbourhood of exhaust air release, air pollution limits may be exceeded. In order to avoid this, in Germany the revised VDI 2053 "air treatment systems for car parks" was changed to make it mandatory to check whether or not regulatory limits are exceeded in the vicinity of newly planned garages.

Key words: car park, air quality, traffic emissions, dispersion, screening model

INTRODUCTION

Air quality in urban areas is not only dominated by such area pollutant sources as traffic, domestic fuel and industry. Recently, more and more people are worrying about local emission sources such as exhaust air outlets of car parks. Because some districts have been transformed into pedestrian zones or parking in them is allowed for residents only, public parking is required. Car parks with more than 1000 parking places are common in urban areas. Pollutants earlier emitted over large areas are released now, highly concentrated, by exhaust air outlets of small extent. As the following example demonstrates, for people living near such outlets, this might be quite relevant. In a car park with 250 places, which was only 30% (daily average) occupied, an emission of 0.5 mg/s of benzene was observed (Zenger, 1998). This is comparable to the emission strength from a street 100 metres long with a daily average traffic volume of 20,000 vehicles. If the exhaust air release is near windows, balconies or children's playgrounds, possible conflicts may occur. Forecasting this pollutant concentration when planning car parks or minimising existing pollution near parking centres is a new aim of air quality policies in urban areas.

SCREENING MODELS

In order to forecast the immission concentration near car park exhaust air outlets, it is necessary to have detailed information about the garage emission strength and atmospheric dispersion in the area around the outlet. While the pollutant release inside a car park can be calculated on the basis of only a few necessary input data (Zenger, 1998), dispersion in urban areas can only be estimated using complex numerical dispersion models. This is such a complicated procedure that, for such a complex situation as emissions in a interrupted street canyon, it cannot be routinely done when planning a new car park. This is why the screening model presented here was developed. With the model, the immission concentration around the pollutant source can be assessed for different standardised building placement configurations and various meteorological situations. This model is no substitute for a detailed dispersion examination with real building geometries. While planning a new car park or in case of existing conflicts, a screening model may help to

- assess maximum immission concentrations and their location for an existing or planned garage even in complex building placement configurations
- compare different locations of ventilation air release in order to minimise air pollution

A dispersion screening model is a simple method to assess the immission concentration for a given source distribution, building placement configuration and meteorological situation. Such models are based on a multitude of results, which have been calculated using complex dispersion models under standard conditions. “Standard conditions” means that the immission concentration $I_{screening}$ was calculated for a fixed

- source distribution
- pollutant release $E_{screening}$
- wind velocity $u_{screening}$
- wind direction
- building placement configuration

For a real situation, that means for a given car park exhaust air outlet in a built-up area and for a given meteorological situation, the immission concentration I_{real} can be obtained by scaling

$$I_{real} = I_{Screening} \cdot E_{real} / E_{Screening} \cdot U_{Screening} / U_{real}$$

By using a screening model it should be possible to assess if air quality problems in the vicinity of car parks will occur or not. The model should reflect a large number of different source distributions and building placement configurations in urban areas. Further, the immission must be calculated as an annual mean and for individual meteorological scenarios, due to the carcinogenic (benzene, soot) and toxic (NO_2, CO) properties of different substances. Therefore it should be possible to integrate individual wind distributions for different cities into the model.

CONCEPT OF THE MODEL

The database of the model presented here consists of more than 8000 concentration distributions, calculated for a standard 2 metre long source emission situated at different places in different building placement configurations. The calculation itself was done with MISKAM (version 3.2), a three dimensional prognostic wind and mixing model (Eichhorn, 1989) which the author tested successfully (Zenger and Weißenmayer, 2001). To get a maximum of variability, the concept used is, that the pollutant distribution around a line source e.g. 8 m long is the same as for 4 neighbouring point sources of 2 m length. By superimposing the immission fields of the individual point sources it is possible to model dispersion around various source distributions. In order to have building placement configurations comparable to those occurring in reality, the question arises which configurations should be adapted to the model. In reality, a infinite number of different combinations of building placement configurations and source locations may occur, which have to be reduced to a realistic minimum. The 5 different building placement configurations which can be chosen in ADIP were selected after examining 60 car parks in 12 German cities. At the moment the user can choose between a

- single building with no surroundings
- long row of buildings interrupted by gaps
- long uninterrupted row of buildings
- street canyon interrupted by gaps
- street canyon

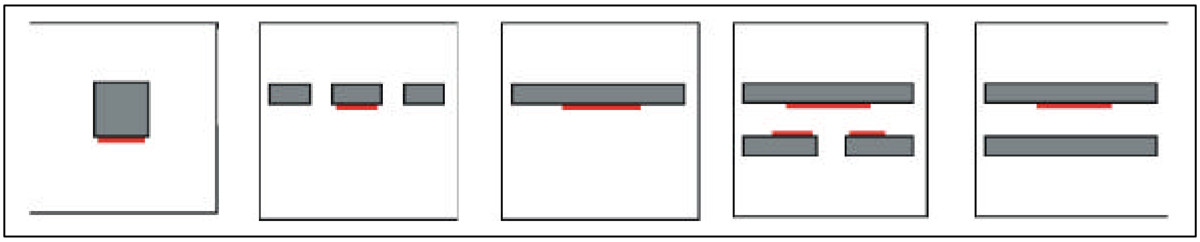

Fig. 1: schematic presentation of different building configurations in ADIP, indicating locations where different point sources can be positioned and combined

More standard building placement configurations will be available soon. For each building configuration, typical dimensions such as height or width can be specified. As an example, fig. 2 shows a car park situated in a real street canyon compared to a similar configuration which can be selected in ADIP.

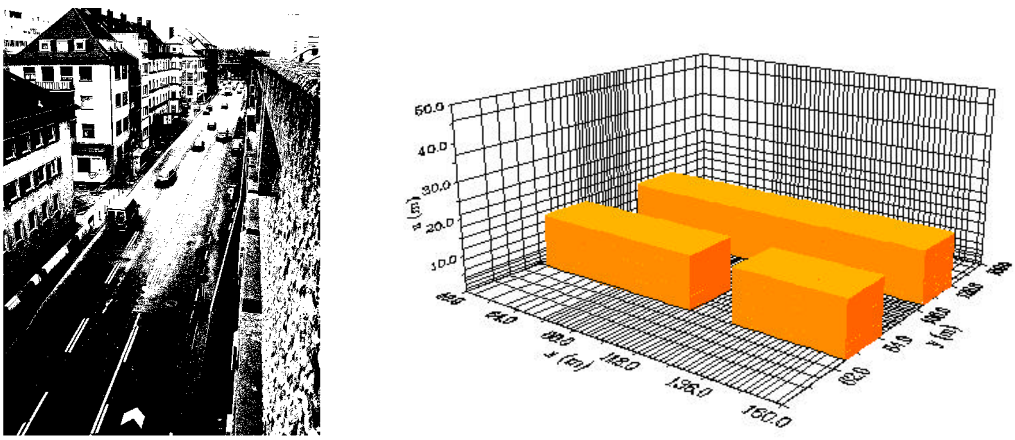

Fig. 2: Car park located in a street canyon compared to a similar building configuration which can be selected in ADIP

In order to estimate the immission concentration around a given car park, the user has to specify the

- building configuration and its geometric dimensions, orientation and location of sources
- emission strength for all relevant substances (benzene, CO, NO_x, soot, etc.)
- annual distribution of wind velocity and direction
- background concentration

Example: Air quality around an underground car park

The underground car park analysed here is to be situated in an combined office and residential building and is supposed to have 241 parking places. The main gate is located in the front of a 17 m high uninterrupted row of buildings (Fig.3). 70% of the emission is due to natural ventilation and is emitted via the entrance gate. The remaining pollutants are emitted through mechanical ventilation via a chimney on the roof. There are several windows located around the entrance.

Fig. 3: Windows in the vicinity of an garage entrance. Such a configuration can be observed quite often in German cities.

The vehicles travel on average 180 metre in the car park. Every day 220 cars enter the garage. Because parking is only allowed for employees, the car park is occupied for only 8 hours a day. With the emission model MOPELIT (Zenger et al., 1998) we get a daily mean emission of 0.4 mg/s benzene, 1 mg/s NO_x and 0.04 mg/s soot. It should be noted that these emission are not only based on theoretical assessments, but on measurements in a real car parks (Zenger et al, 1998). In ADIP we find a similar building configuration, a long uninterrupted row of buildings. Three alternate building heights of 15, 20 and 25 metres can be selected. For this example, 15 m is chosen as being closest to the actual height. Next, the line source of 6 m (entrance width) and area-specific wind distribution are selected and the calculation is started. As a result, fig. 4 shows the calculated distribution of benzene additional immission load around the entrance.

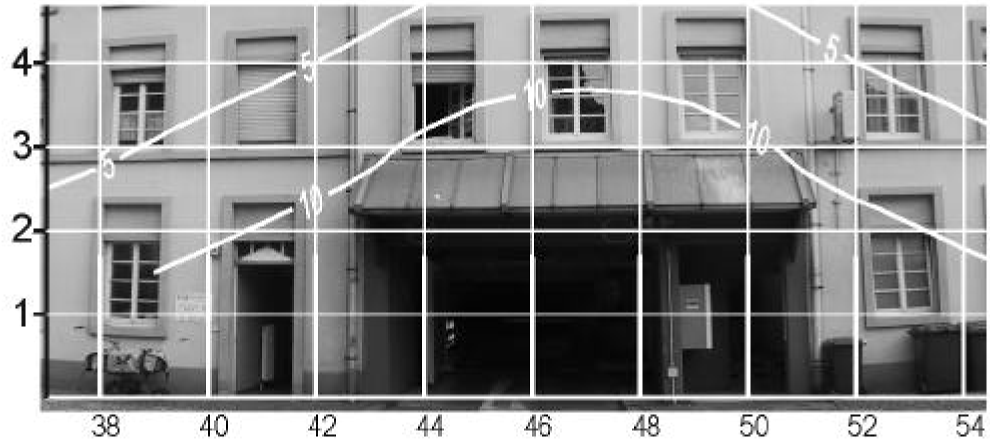

Fig.4: Calculated distribution of benzene additional immission load around the entrance of a car park. All distances in metres.

As can be seen, at the windows near the entrance a mean additional benzene immission load of up to 10 µg/m³ may occur annually. Here the background immission concentration of about 2 µg/m³ is not taken into account. By comparing the result to the benzene immission levels of 5 µg/m³ permitted, the example demonstrates that in the neighbourhood of even medium size car parks, immissions may exceed regulatory limits. In order to avoid this, in Germany the VDI 2053 "air treatment systems for car parks" was changed to make it mandatory to check whether limits are exceeded.
A demo – version of the screening model ADIP can be downloaded from www.metsoft.de

Works cited:

Eichhorn, J. (1989): Entwicklung und Anwendung eines dreidimensionalen mikroskaligen Stadtklima- Modells. Dissertation Universität Mainz. 1989.

Rau, M., A. Zenger (2001): Entwicklung eines benutzerfreundlichen Screening-Modells zur Abschätzung der Immissionskonzentrationen im Nahbereich von innerstädtischen Parkanlagen und Tiefgaragen. Final Project Report 08391, Federal German Environmental Fundation.

Zenger, A. (1998): Luftqualität in und um Tiefgaragen, Immissionschutz 4, 1998 und 1, 1999.

Zenger, A. (1999): Gesundheitliche Relevanz von Tiefgaragenemissionen, Wohnmedizin und Bauhygiene, Volume 6, December 1999.

Zenger, A., T. Gritsch U. Höpfner, M. Sinn, P. Rabl, N. van der Pütten, H. Gabler.(1999) : Predicting Emission and Mean Air Quality in Underground Garages. Proceedings of 8th Intl. Conference on Traffic and Environment and COST 319, Graz, Austria.

Zenger, A., H. Simon (2001): Ermittlung typischer Gebäudekonfigurationen in der Umgebung von Pkw-Tiefgaragen sowie Erfassung weiterer Garagen-Kenngrößen. FH Mainz, 2001.

Zenger, A and Weißenmayer (2001): Datensatz zur Verifizierung mikroskaliger atmosphärischer Ausbreitungsmodelle, Immissionsschutz 4 /2001.