AIR QUALITY ASSESSMENT IN THE EUROPEAN MEGA CITY RUHR AREA

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Overview

The Ruhr area is the biggest German megalopolis, a conglomerate of several intertwining major cities, with more than 3.5 million inhabitants. In spite of many efforts in recent years to improve the air quality in the Ruhr area, especially residents in street canyons with a high traffic density are still exposed to poor air quality, and meeting the limit values of European air quality directives 96/62/EC and 1999/30/EC for PM_{10} and NO_2 remains a challenge.

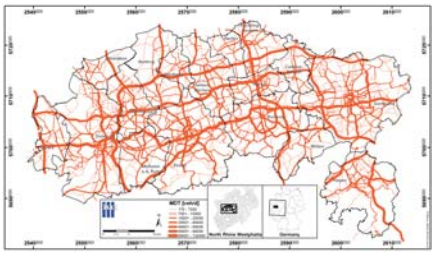
As the assessment of air quality for a large area with measurements only is both impracticable and unaffordable, in this study the hot spots in the area have been identified and assessed by a model-based approach. Calculated results for total concentrations were analyzed statistically, leading e. g. to the total length of inhabited street sections affected by violations of the respective limit values and displayed cartographically in colors green (good), orange (intermediate) and red (poor), as so-called "traffic light maps".

The total concentration of a pollutant in a street canyon is the sum of the "regional background" caused by sources outside the study area, the "local background" caused by sources within the study area, and the "additional concentration" caused by the road traffic in the street canyon itself. Background concentrations were calculated with different models and contributions of industry, shipping, rail traffic, off-road traffic and heating were modeled separately, such that source apportionments are easily available.

The additional concentration is influenced mainly by the traffic load of and the building situation along the street. So, the road network of the Ruhr area with 3000 km in length was mapped with housing data in order to identify inhabited road sections and additional concentrations were calculated with a screening model.

Major road network with traffic and emission load

The georeferenced major road network with information on traffic load was used to calculate emissions from road traffic for the background and the additional concentrations and as basis to derive inhabited street sections.



Additional concentrations in inhabited street sections

Building situation

The additional concentration in the street canyon itself is influenced mainly by the traffic load of and the building situation along the street. In the screening model IMMIS^{luft} used in this study, the building situation is parameterized by the

- height of the buildings along the street,
- width of the street canyon, and
- building density (i. e. gaps between buildings) along the street.

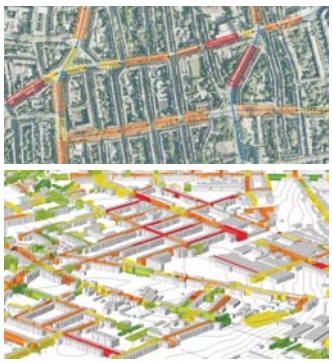
Therefore, the entire road network had to be transformed into sections which are homogenous with respect to these parameters, and the numeric values of the parameters had to be derived. This was done using a semi-automatic GIS-based approach based on the road network and building data consisting of footprints and heights of the buildings (LoD1 model).

Additional concentration

The additional concentrations in the thus formed 8044 street sections were calculated with the screening model IMMIS^{luft}. The model has been developed to calculate traffic-induced air pollution in urban streets. It is based on the CPB model for street canyons and a box model for open building structures.

Municipality	number of sections	Municipality	number of sections
Bochum	767	Hagen	544
Bottrop	224	Herne	366
Castrop-Rauxel*	29	Herten	147
Dinslaken	141	Moers	138
Dortmund	1457	Mülheim a. d. Ruhr	444
Duisburg	1094	Oberhausen	567
Essen	1158	Recklinghausen	285
Gelsenkirchen	425	Witten	202
Gladbeck*	56	**Sum**	**8044**

*Municipalities with incomplete building data

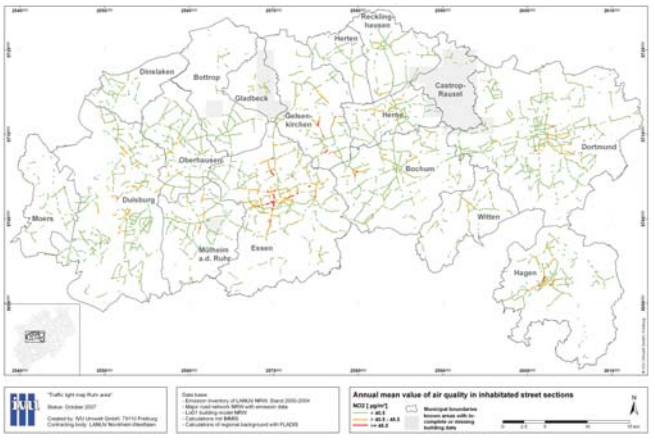


Work-in-progress generating the street sections: top and oblique view with sections displayed corresponding to their width and height, classified according to gaps between buildings (green = many to red = few)

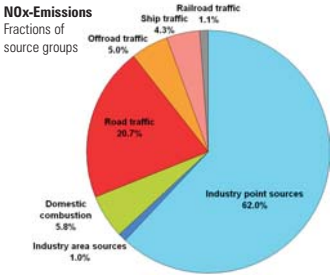
"Traffic light maps" for NO_2 and PM_{10}

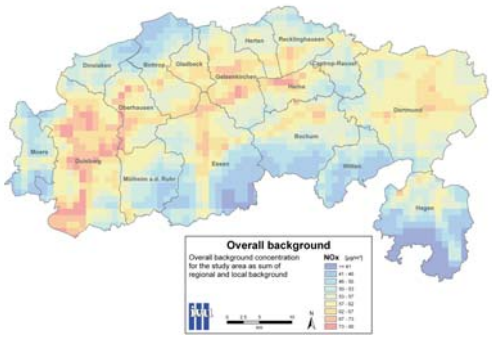
The so called "traffic light maps" show the total concentratios in the inhabited street sections classified in green (good), orange (intermediate) and red (poor). The total concentration for a street section is the sum of the background and the additional concentration.

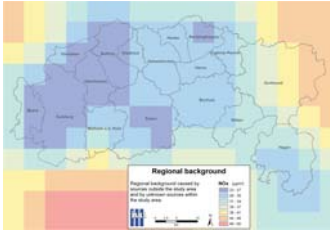
The traffic light maps provide both detailed screening results and a good overview over the air quality situation in the area.



Determination of background concentrations



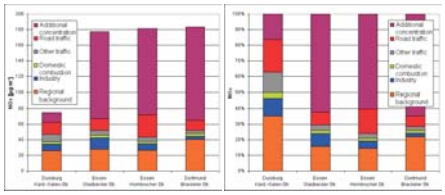




Based on spatially distributed emission data (point-, line- and area-sources), local background concentrations were calculated with IMMIS^{net} for a 1 x 1 km² grid as well as for each street section. The regional background was determined by combining the calculations of the chemistry transport model EURAD with a resolution of 5 x 5 km² with observations of the air quality monitoring network. The combination of the data results in the overall background concentrations for the area and the specific street sections.

Source apportionment

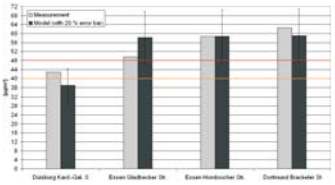
Separate calculations for each source group allow for source apportionment at the hot spots which are an important means to identify main polluters.



Absolute and relative contributions of different source groups to total NO_x concentrations

Validation

A comparison of the calculated total concentrations with measured values at four hot-spot stations in inhabited sections in the Ruhr area shows the quality of the model system.



Comparison model vs measurement for NO_2 annual mean values with threshold values of the traffic light map

Outlook

The results of this approach are a sound basis to assess the potential of various measures to improve air quality in the area. Low emission zones, for example, were analyzed in a follow-up project. Furthermore, the results are a good guideline for an optimal placement of measurement stations.