COMPARING THE IMPACT OF A ROAD TUNNEL VERSUS A ROAD VIADUCT BY MEANS OF AN INTEGRATED EXPOSURE ASSESSMENT

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INTRODUCTION

We calculated the emissions and concentrations of PM_{10} and NO_2 for a road tunnel and a road viaduct, foreseen as a means to close the ring road around Antwerp, a major city in the north of Belgium. One of the criteria on which the choice between these two road constructions will be based is a detailed air quality assessment. The results were evaluated against the limit values presented in the EU directives on ambient air quality assessment and management (1999/30/EC). The calculated PM_{10} and NO_2 concentrations were further used to assess the exposure of the population in Antwerp living in the vicinity of the planned constructions. Section 2 describes the MOBILEE methodology which was used for this study. Further exposure assessments were based on the impact pathway methodology, which is discussed briefly in this section as well. Section 3 summarizes the main results of the study and discusses briefly its main implications with respect to the construction works.

METHODOLOGY

The assessment was carried out using the integrated MOBILEE approach. This approach combines road transport emission calculations (*Mensink, C. et al.*, 2000) with dispersion and exposure modelling. The dispersion modelling is based on the coupling of two models: the street canyon model OSPM (*Berkowicz, R.*, 1998) and the Gaussian model IFDM (*Cosemans G. et al.*, 1997). OSPM is a street canyon model and calculates the contribution of the traffic emissions inside a particular street. IFDM is a Gaussian dispersion model and computes the background contributions. This includes not only the contribution from industrial stacks and domestic heating within a domain with a 20-30 km radius (larger Antwerp region), but also the concentration levels caused by traffic in the surrounding streets.

The exposure assessment is based on the impact pathway methodology (see Figure 1), as discussed extensively by *Friedrich, R. and P. Bickel* (2001). The impact pathway method follows the fate of pollutants along the steps in the DPSIR chain: Drive (human activities), Pressure (emissions), State (air quality and exposure), Impact (health, economic) and Response (policy). The evaluation of environmental impacts is based on the accounting framework of the European ExternE project. Using the ExternE methodology, estimations of the environmental damage costs related to the impacts can be provided.

The MOBILEE methodology has been applied for a reference situation (2003), the ring road closure by means of a tunnel and the ring road closure by means of a viaduct. Three corresponding mobility scenarios were used to calculate the traffic emission. The mobility scenarios are based on the current situation (1), the closure of the ring road by means of a viaduct (2) and the closure of the ring road by means of a tunnel (3). In all scenarios the number of vehicles and the composition of the traffic fleet was identical and based on the situation in 2003. For the tunnel scenario, two exhaust heights have been studied. In a first case, the emission height was set at 5 m. In the second case an emission height of 30 m. was used. Note that all scenarios include a part in which a tunnel is running underneath the Scheldt river. The exhaust height for this part of the ring road was set at 5 m.

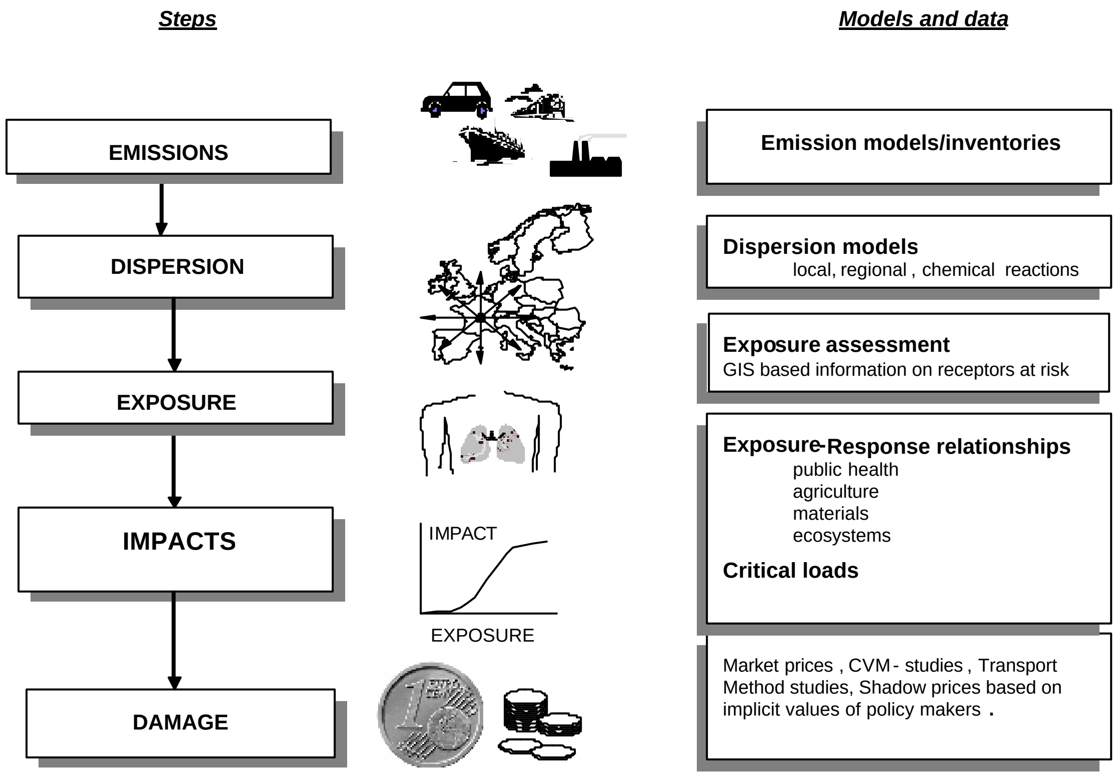

Figure 1: Integrated assessment framework: the impact pathway methodology.

RESULTS

Emissions

Table 1 gives an overview of the annual emissions (2003) for NO_x and PM_{10} in the viaduct scenario and the tunnel scenario. Note that the differences are very small and associated with a slight modification in the trajectory. For comparison, Table 1 also shows the total annual traffic emissions in the neighborhood and the total annual traffic emissions in Flanders in 2003. Another remark is that the exhaust pipe of the tunnel does not include any filter installation

Table 1. Annual NO_x and PM_{10} emissions for the viaduct scenario and the tunnel scenario in comparison with emissions in the neighborhood and with total traffic emissions in Flanders.

Scenario	NOx (tons/year)	PM_{10} (tons/year)
Viaduct scenario	201,2	8,15
Tunnel scenario	197,7	8,0
Ring road neighbourhood	709	31
Traffic in Flanders	87488	4384

Annual PM_{10} and NO_2 concentrations

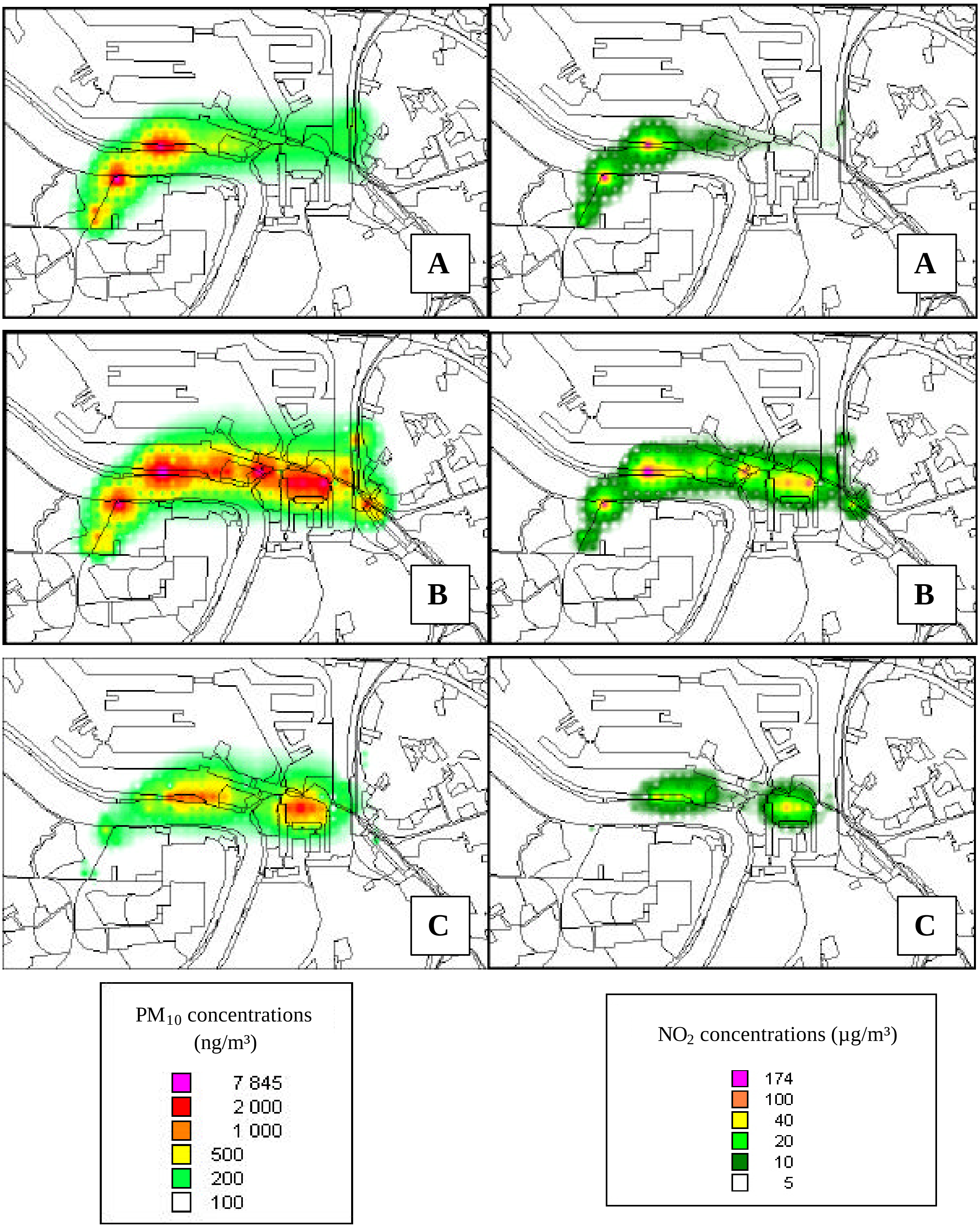

Figure 2. Calculated increase in annual PM_{10} concentrations (left panels) and annual NO_2 concentrations (right panels) for A) the viaduct scenario; B) the tunnel scenario with exhaust height of 5 m. and C) the tunnel scenario with exhaust height of 30 m.

Figure 2 shows the annual NO_2 and PM_{10} concentration increments resulting from the comparison of the viaduct scenario (A) and the tunnel scenario (B and C) with the 2003 reference case. From figure 2 we can learn that the emission exhaust height in the tunnel scenario is a decisive parameter. This becomes clear when comparing plots B and C. In both figures the coloured areas correspond with the parts of the tunnel scenario where an "open" tunnel exists, i.e. a part of the tunnel that is not covered. The highest concentrations are obtained for the tunnel variant with an exhaust height of 5 m. The expected total increase in PM_{10} concentrations in case of the tunnel variant with an exhaust height of 30 m. is approximately 1 µg/m³. Locally the NO_2 concentrations are expected to rise in this scenario with 20 µg/m³.

Figure 3 shows the calculated distribution of the annual NO_2 concentration over the city of Antwerp for 2003 and for 2015, when the road constructions are expected to be implemented. Results for 2015 are presented for the tunnel scenario (C). We can clearly observe the structure of the impact of the ring road and highways in 2003. When comparing the situation in 2015, one can observe that there is a only a minor impact of the new road constructions and that there is a large overall reduction in NO_2 concentrations expected. This reduction is due to a sharp decrease in emission factors that is expected for 2015.

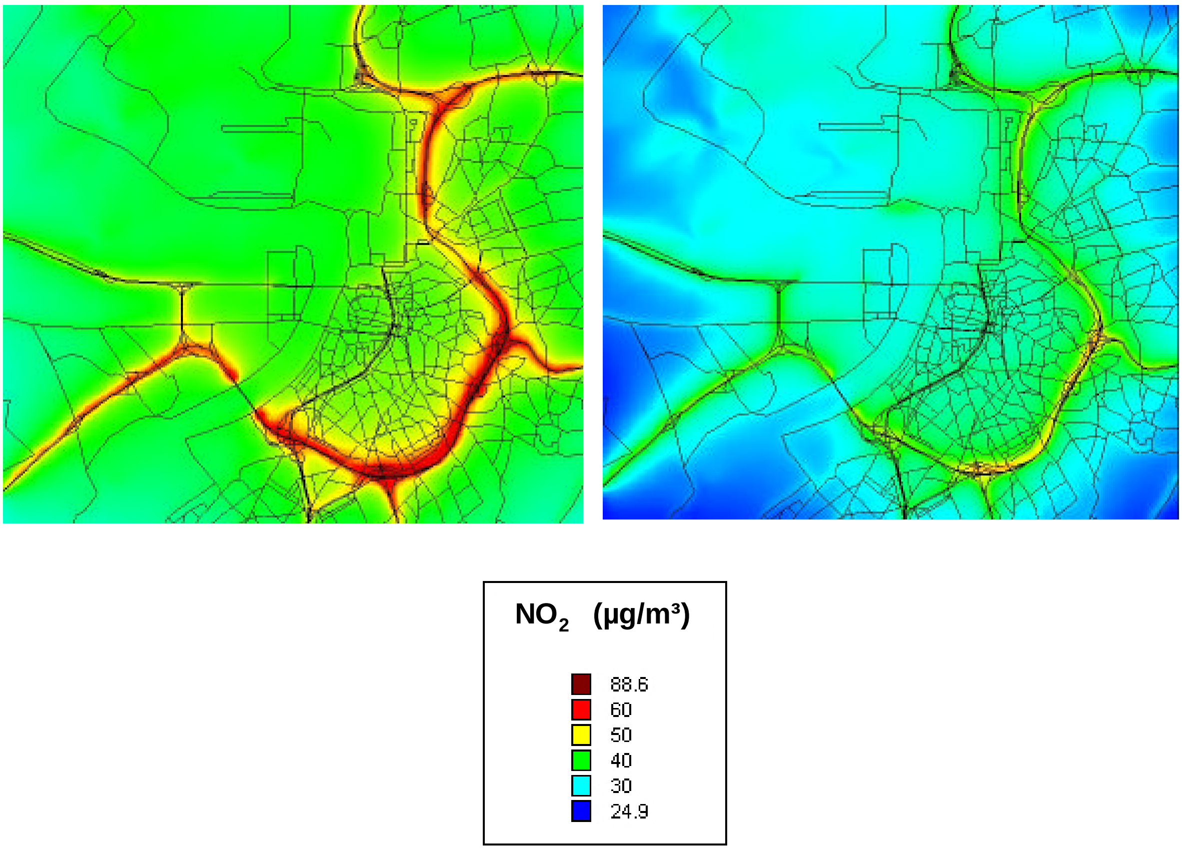

Figure 3. Calculated annual NO_2 concentrations for the reference case in 2003 (left panel) and the situation in 2015 after implementation of the tunnel scenario (right panel).

Exposure calculations

The exposure results were obtained by using a GIS map with detailed information of the population density in the Antwerp area. Thus exposure is evaluated in a static way. Note that most people who will be affected by the new road are living east of the tunnel or viaduct. In terms of exposure assessment, PM_{10} is the dominant parameter. However, an evaluation of the population exposure for the three situations demonstrates that the differences are not very significant in absolute terms, because of the high background concentrations for PM_{10}. Compared to the impact of the viaduct, a tunnel with an exhaust at a height of 5 m. shows an *increase* in total exposure of 40%, whereas a tunnel with an exhaust height of 30 m. shows a *decrease* in total exposure of 5%. A further consideration with respect to the tunnel situation is the possibility to apply filter installations in order to further reduce the concentrations.

Note that the exposure calculations have been based on data for 2003, whereas the inauguration of this new part of the ring road is foreseen in 2015. By this time the fleet composition, the traffic emission factors and possibly the population distribution might have been changed considerably. This effect has not been quantified nor been taken into account by the study.

CONCLUSIONS

The MOBILEE methodology has been applied to study different scenarios for the ring road closure in Antwerp, a major city in the north of Belgium. Three mobility scenarios were used to calculate the traffic emission: a ring road closure by means of a viaduct and a ring road closure by means of a tunnel, varying the exhaust height between 5 m. and 30 m..

The evaluation of the population exposure for the three situations demonstrates that the differences are not very significant in absolute terms, because of the high back ground concentrations for PM_{10}, being the dominant parameter in the exposure assessment. A tunnel with an exhaust height of 5 m. shows an *increase* in total exposure of 40% when compared to the viaduct scenario. A tunnel with an exhaust height of 30 m. shows a *decrease* in total exposure of 5% when compared to the viaduct scenario.

Exposure will decrease considerably in 2015 due to an expected sharp decrease in traffic emission factors. Compared to the expected reductions in 2015, the road constructions will only have a very limited impact.

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