Air quality monitoring and modelling near a lead works

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1 Introduction

The directive 96/62/EC allows, under certain conditions, for the use of air quality models for the assessment of ambient air quality.
In eight monitoring sites, located around a lead works (Figure 1) near Antwerp, Belgium, daily mean concentrations of airborne lead are measured since 1977.
We will investigate whether this monitoring network can be replaced in all or in part by air quality modelling.

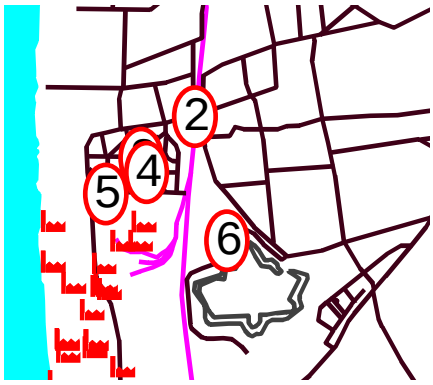

Figure 1 Some of the 8 monitoring sites near the Antwerp lead works.

2 Dispersion Modelling

The study is conducted using the immission, emission and meteorological data for the two year period 1996-1997. During this period, 12 metric tons of lead per year are emitted through 29 stacks of the lead works. These emissions, together with the heat content of the stack gasses and the stack height, are used to calculate the concentrations of lead in ambient air near the factory, using the IFDM-model[1]. According to these calculations, the emissions through the stacks contribute for only 6% to the concentrations measured near the fence of the lead works yard and for about 20% to the concentrations measured at 4 km from the plant.

2.1 Importance of diffuse emissions

The fact that stack emissions contribute for only a small fraction to the measured concentrations of heavy metals near a non-ferrous metal smelter was already demonstrated during an in depth study of the dispersion of antimony near an antimony smelter in 1978-1981[2]. Here, fly-ash and antimony compounds with a morphology typical for stack flue gas were found only at 4000 m distance downwind from the stacks, while the morphology of antimony particles in ambient air at 200 m to 1500 m from the smelter were similar to that of the particulate found in the work places from where diffuse emissions originated.
It is very difficult to measure the diffuse emissions of a non-ferrous metal plant. In order to proceed with this study, we used reverse modelling to estimate the diffuse lead emissions. Diffuse emissions

should be about 6 tons of lead per year. Taking into account these diffuse emissions, the agreement between measured and IFDM-calculated two year average concentrations is good. For monitoring sites under the dominating wind direction, we find:

at 10 m from the fence:	1286 ng/m³ measured versus 1210 ng/m³ modelled;
at 250 m (two monitoring sites):	772-633 ng/m³ measured and 770-650 ng/m³ calculated;
at 600 m:	399 ng/m³ measured and 346 ng/m³ modelled;
at 4 km :	78 ng/m³ measured and 35 ng/m³ modelled. Lead emissions by traffic (not included in the calculations) are important at this site

Similar agreement was found for the percentiles in the range from P50 to P99.5.

2.2 Wind speed dependency

A further analysis of measured and calculated daily mean concentrations (Figure 2a) revealed that about 50% of the diffuse emissions are varying in time proportional to (the third power of) the wind speed.

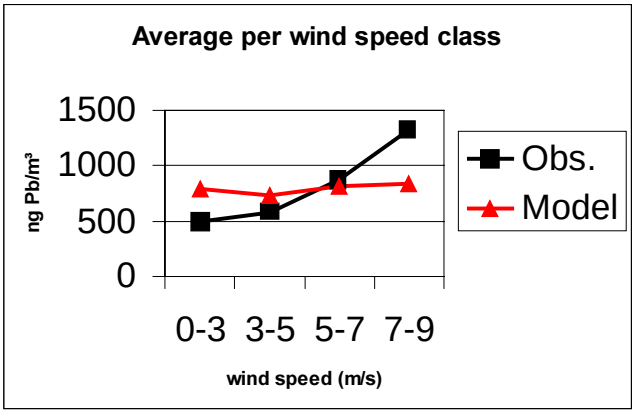

Figure 2a Modelled day-averaged concentrations using constant fugitive emissions do not vary with day-averaged wind speed, while measured 24-h concentrations do vary a factor 3 over the different wind speed classes.

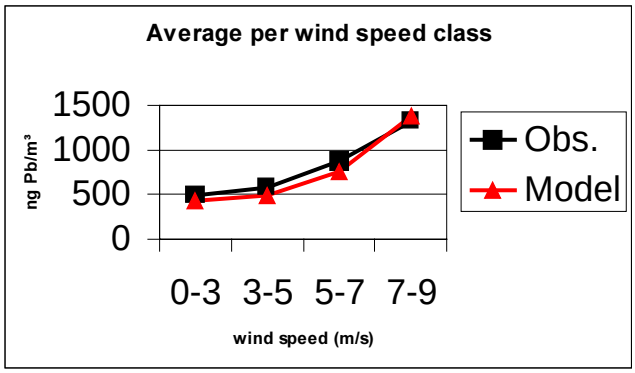

Figure 2b Modelled day-averaged concentrations using wind speed-dependent fugitive emissions vary with day-averaged wind speed in a way comparable to the measured 24-h concentrations.

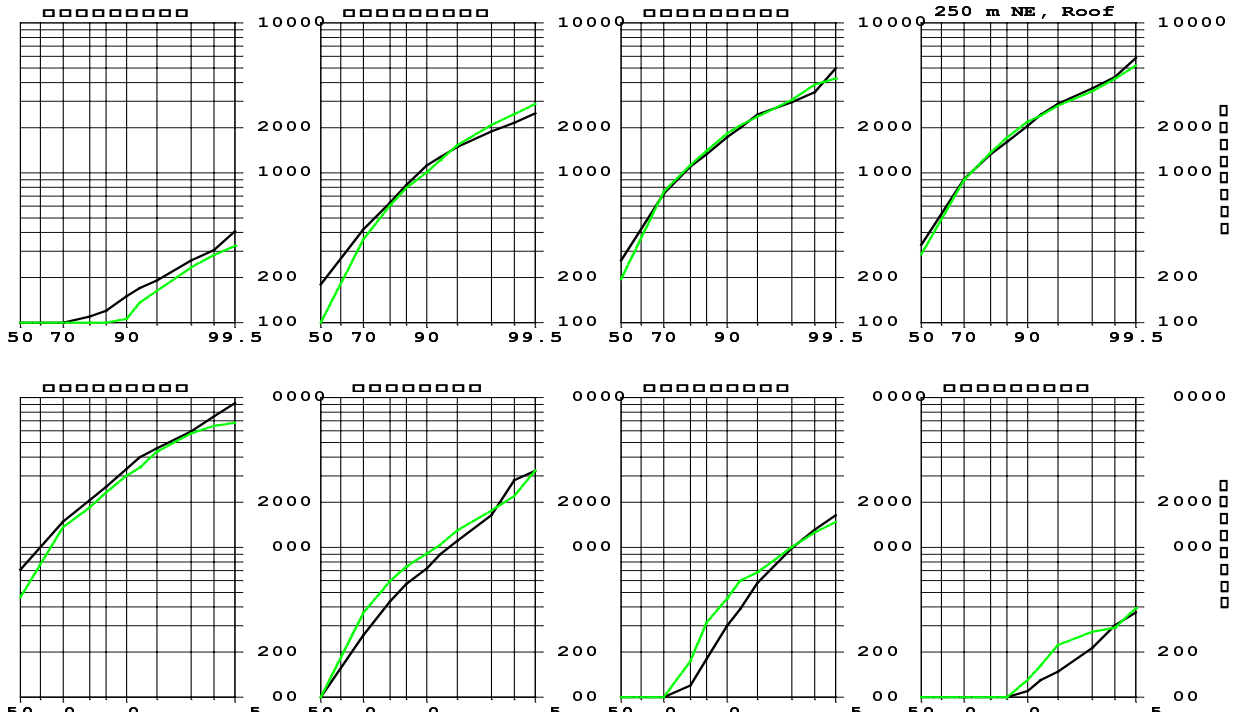

Figure 3 Cumulative frequency distribution of measured and calculated day-averaged Pb-concentrations in 1996-1997.

The cumulative frequency distribution of measured and calculated concentrations (Figure 3), as well as the pollution roses (Figure 4), are very similar.

3 Conclusions

The existing monitoring network can not be replaced by modelling only. Some monitoring sites will be needed to assess the evolution in time and space of the diffuse emissions that dominate the ambient air pollution by lead in the vicinity of the lead works.

References

1. Bultynck, H. and Malet, L. (1972), 'Evaluation of atmospheric dilution factors fot effluents diffused from an elevated continuous point source', *Tellus*, No. 24, pp. 445-472

2 De Wispelaere, C., Vanderborgth, B. *et al*. 'Air pollution near a non-ferrous metal industry, a comprehensive study', Volume 20 of the Final Scientific Report, National R&D Program on Environment-Air, Services of the Prime Minister, Brussels, /1982/1191/5/20 , 376 pages. (Availability might be limited. 56 co-authors from 14 universities and laboratories, covering 9 scientific disciplines. The document is written partly in Dutch, partly in French. Author Guido Cosemans has a copy of this report.)

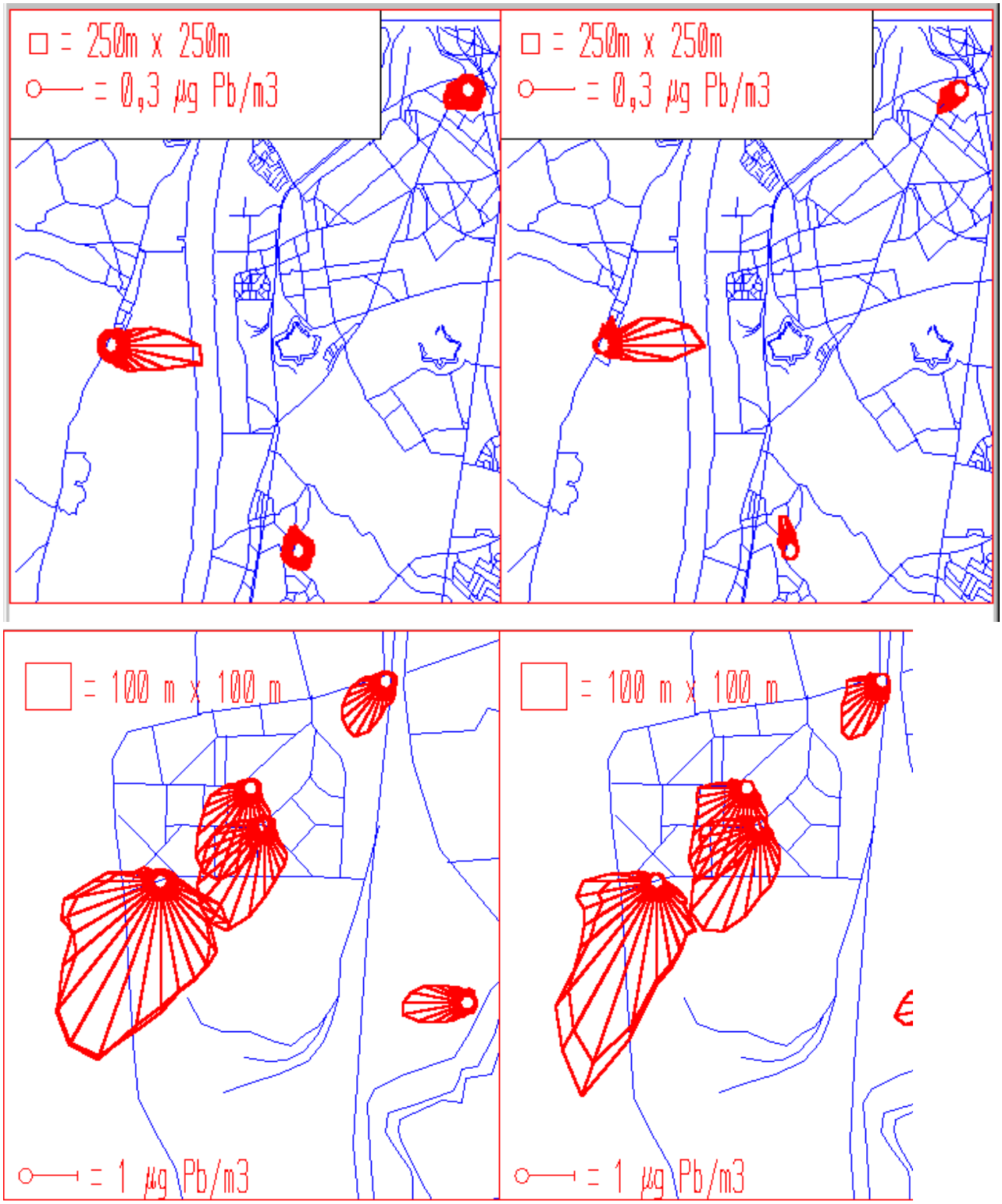

Figure 4 Pollution roses of measured (left) and calculated (right) Pb-concentrations in ambient air.