PM and NO_2 at urban sites with different traffic exposure: curb site measurements in Flemish cities

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Abstract

Road transport is known as one of the main sources of urban air pollution, especially PM and NOx. The knowledge that PM may induce adverse health effects is an incentive for progressive cities to evaluate local air quality and to consider what action should be taken. Existing air quality measurement networks measure air pollution at different sites and give an 'average value' for the surrounding area. However, most of these measurement stations are not located at hot spot locations, e.g. close to busy roads. The aim of this study is to assess the air quality at urban (curb site) locations.

PM_{10} daily average values were measured during 3-4 weeks at six locations representing different 'typical' traffic locations: e.g. ring road, access road, parking route, local traffic. NO_2 was measured at all locations.

At the background location lowest concentrations were measured for all parameters. Differences in PM_{10} and NO_2 were observed between the different locations. It seems that NO_2 is more sensitive to traffic exposure than PM_{10}. This is due to the higher background and background variation of PM_{10}. The highest NO and NO_2 values were measured at the bus location,. Highest concentrations of PM_{10} and black carbon are measured at the ring location. However some trends could not be explained.

Keywords: PM, NO_2, urban, traffic, black carbon.

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1 Introduction

Numerous epidemiologic studies have documented adverse health effects of air pollution. Recently, studies have reported associations between residential proximity to busy roads and a variety of adverse respiratory health outcomes in children. Moreover, it was shown that traffic related pollution (PM, NOx and black carbon) is associated with respiratory symptoms in children [1].

The knowledge that PM may induce adverse health effects is an incentive for progressive cities to evaluate local air quality and to looking for actions to be taken. Before cost effective measures can be taken, the actual air quality of the city has to be assessed in order to identify hot spot locations.

Existing air quality measurement networks measure air pollution at different sites and give an 'average value' for the surrounding area. However, most of these measurement stations are not located at hot spot locations, e.g. close to busy roads. In Flanders, the daily average limit value for PM_{10} was exceeded more than 35 times in 17 of 31 monitoring sites in 2005 [2].

Some of the larger Flemish cities have implemented innovative transport and mobility policies in the past decade. Before supplemental cost effective measures can be taken, the actual air quality of the city has to be assessed in order to identify hot spot locations.

The aim of this study is to assess the air quality at urban (curb site) locations.

2 Experimental set-up

2.1 Monitoring sites

The monitoring campaign has been performed in spring (from 15/5 – 18/6) at six sites in the city of Ghent. The selected locations are characterised by different exposure to traffic (see Table 1) e.g. ring road, access road, parking route, local traffic. Traffic counts during morning rush hours (7.30 – 8.30 local time) are displayed in the table for cars and heavy duty (HD) vehicles including buses.

The monitoring sites were selected using emission modelling results, a short screening measurement campaign and information on traffic intensities provided by the local authorities.

The measured concentrations are also compared to data of nearby monitoring stations of the air quality monitoring network.

2.2 Experimental techniques

PM_{10} measurements are performed according to the EU reference method (EN 12341) using a sequential high volume sampler [3].

Filters are analysed with a Smoke Stain Reflectometer to determine black smoke. Particle reflectance of the sampled filters was measured using a reflectometer and transformed into an absorption coefficient according to ISO 9835 [4]. Absorption coefficients were transformed into black smoke concentrations ($\mu g/m^3$) using the method of Roorda-Knaepe et al [5]. Although

black smoke concentrations calculated by this method have a lower accuracy compared to direct EC determination on quartz filters, the method is used here for comparison of different sites.

A mobile emission laboratory is used during one week (at each location) to measure the weekly profile of NO_2 and PM_{10}. NO and NO_2 are measured using a NO/NOx chemiluminescence analyser. PM_{10} profile is measured with TEOM-FDMS which is provided with an aethalometer module for the measurement of black carbon.

Diffusive samplers were used to measure weekly/monthly average NO_2 concentrations.

Table 1: Description of monitoring sites.

Site	Description	traffic counts during morning rush hours (7.30 – 8.30)	
		nr of cars	nr of HD
G1	**background** quiet residential area with only local traffic	40	3
G2	**ring road** ring road location in the north of Ghent with a lot of car traffic and heavy traffic	3180	292
G3	**street canyon – access road** one-way traffic in the city centre in a street canyon	257 **(1)**	28 **(1)**
G4	**parking route – access road** this location is part of a signposted parking route for incoming traffic	**(2)**	**(2)**
G5	**busy city traffic – at waterside** location characterised by busy city traffic next to a waterway	386	18
G6	**bus traffic** location next to the railway station with a lot of bus traffic	**(3)**	**(3)** nr of buses: 508 - 1010

(1) data given are values for evening rush hours**.**
(2) no data available. During morning rush hours traffic-jams are formed.
(3) no data available. Nr. of buses: between 508 (Sunday) - 1010 (schooldays)**.**

3 Results and discussion

3.1 PM_{10} concentrations

The figure below shows the PM_{10} concentrations at all locations and at two nearby stations of the air quality monitoring network. One of them is an urban

station located in the city of Ghent (referred to as 44R701) the other is an urban background station (referred to as 44R710) situated at the east of Ghent.

At location G1 the lowest concentrations were measured. This location is a quiet residential area with almost no traffic and was chosen at the start of the study as background location.

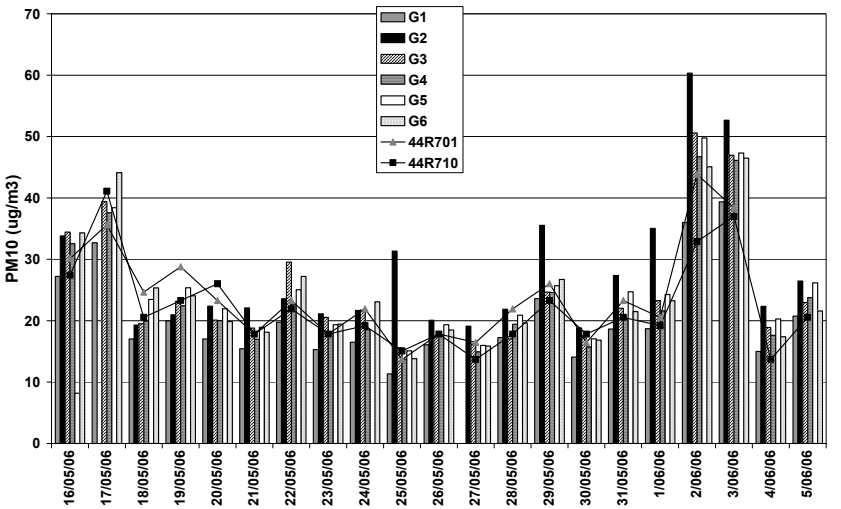

Figure 1: Daily average PM_{10} concentrations ($\mu g/m^3$) measured at six locations in Ghent (G1–G6) and 2 stations of the air quality monitoring network (44R701 and 44R710).

The difference in PM_{10} concentrations compared to the background location is shown in Figure 2. This gives an idea of the contribution of local sources such as traffic. A summary of the distribution of daily average PM_{10} concentrations for different locations is given in Figure 3. The average difference is 8 $\mu g/m^3$ at G2 and 3–5 $\mu g/m^3$ at locations G3–G6.

The smallest increase in PM_{10} concentration was found at location G4 although this was a location with a lot of traffic and traffic jams. During the measurements however, there was less traffic because adjoining streets were closed due to road works.

The higher average increase in PM_{10} concentration measured at G2 was due to some days with excessive PM_{10} concentrations compared to other days at this location. It was observed that the higher concentrations occurred at days with wind coming from north-west. The measurement system was situated at the south-east of the crossing. This intersection is one of the busiest in town. It is also possible that other sources than traffic contribute to the observed higher concentrations. It must be mentioned that at some days with excessive PM_{10} concentrations at G2, also higher background (G1) concentrations were measured (see Figure 1).

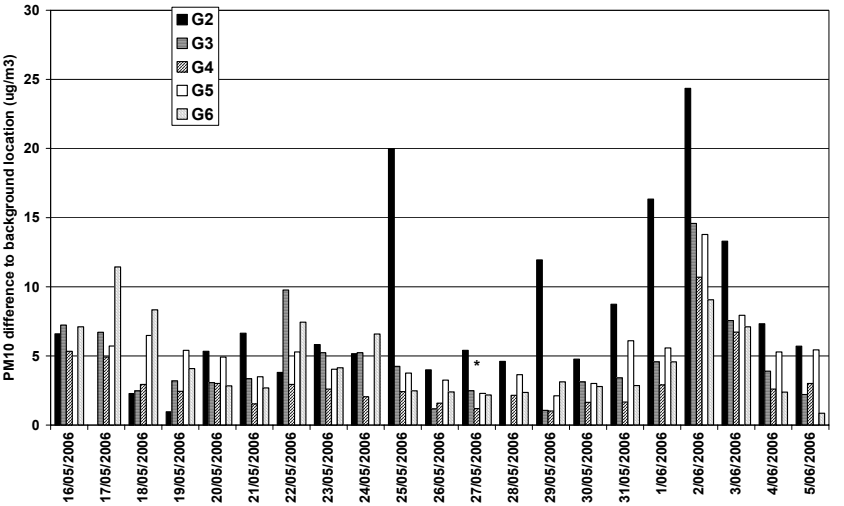

Figure 2: PM_{10} concentrations difference ($\mu g/m^3$) at five locations compared to background location G1 in Ghent. (*27/5/06: PM_{10} concentration difference compared to 44R710 because no data at background G1 was available.)

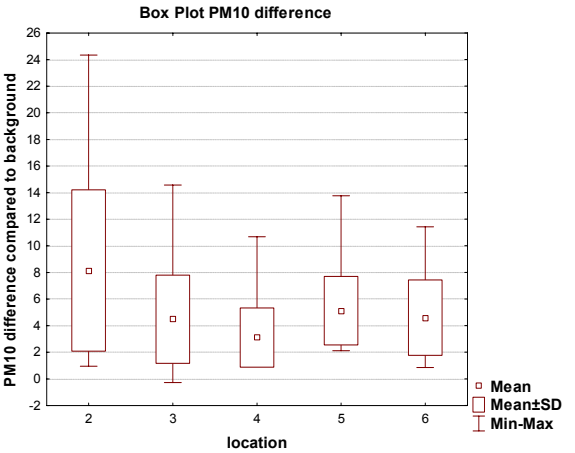

Figure 3: Distribution of the daily average PM10 difference at five locations compared to background location.

3.2 Black smoke

Figure 4 shows the black smoke concentrations ($\mu g/m^3$) measured on filter using reflection technique. Note that the resolution of this technique is not better than

1 μg/m^3. Therefore some unrealistic negative values are observed at low concentrations.

During the episode of high PM_{10} concentrations at location G2, also high concentration of black smoke are measured indicating that this is a carbon related source. The second highest values are measured at G3 and G6, representing a street canyon location and a location exposed to bus traffic.

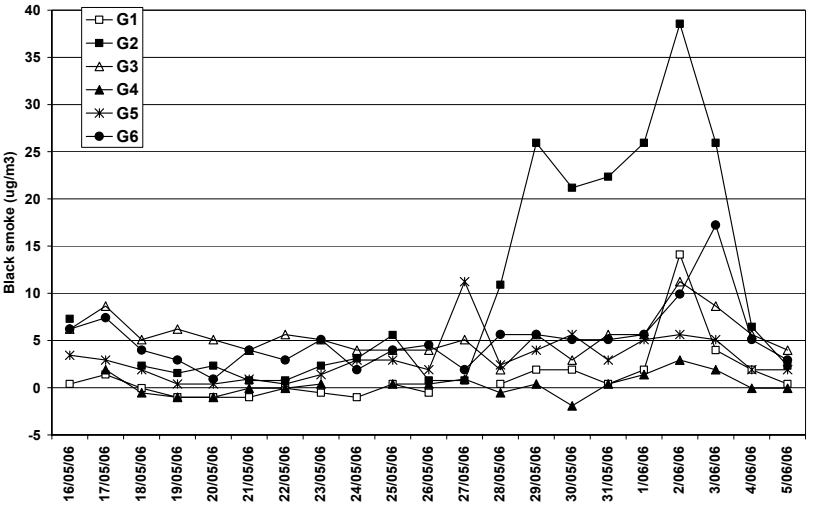

Figure 4: Black smoke concentration (μg/m3) calculated from reflection measurements on sampled filters at six locations.

Table 2: Distribution of the black smoke concentrations at 6 locations in Ghent.

Site	G1	G2	G3	G4	G5	G6
Average	1	10	5	3	0	5
Standard deviation	3	12	2	3	1	3
Minimum	-1	1	2	0	-2	1
Maximum	14	39	11	11	3	17

Black carbon concentrations measured using an aethalometer are summarised in Table 3. As already stated, measurements are not executed at the same time resulting in differences in background concentrations. Therefore, next to the black carbon concentration, also the ratio of black carbon to PM_{10} (measured with TEOM-FDMS) is given.

The highest black carbon concentration is measured at location G2. The lowest concentration is measured at the background location G1. At location G3 and G6 similar values were measured, which was also observed for black smoke concentrations.

Table 3: Black carbon concentrations measured using aethalometer at five locations in Ghent.

Site	Black carbon ($\mu g/m^3$)	black carbon / PM_{10} ratio (%)
G1	1.3	3.2
G2	3.7	8.4
G3	1.6*	6.7*
G4	2.8	5.0
G6	1.9	7.1

* results based on limited data (2 days).

3.3 NO and NO_2 concentrations

NO and NO_2 were measured at five of the six locations, during about one week each. The results are given in Figures 5 and 6. Since NO and NO_2 concentrations at the different locations are not measured simultaneously, the concentrations measured at different locations are compared to the concentrations measured at the urban station (44R701) of the air quality monitoring network.

At the background location, the concentrations for both NO and NO_2 are similar to the urban station.

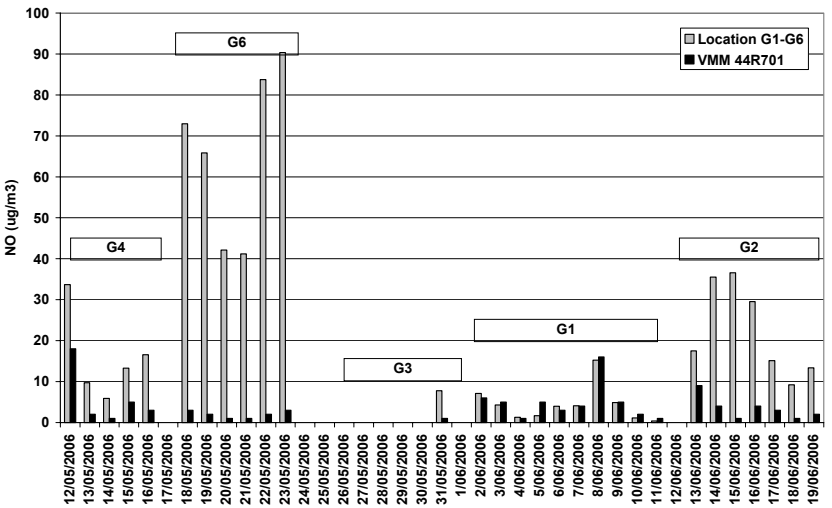

Figure 5: Daily average NO concentrations ($\mu g/m^3$) measured with monitor at five locations.

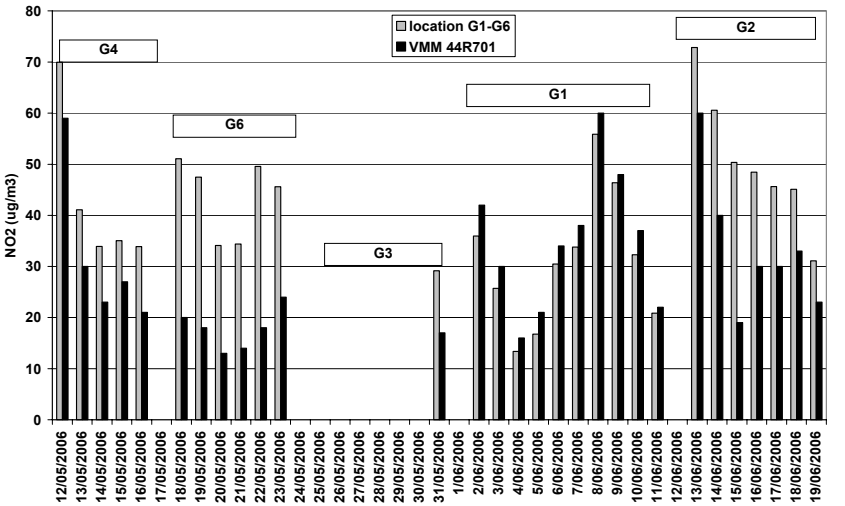

Figure 6: Daily average NO_2 concentrations ($\mu g/m^3$) measured with monitor at five locations.

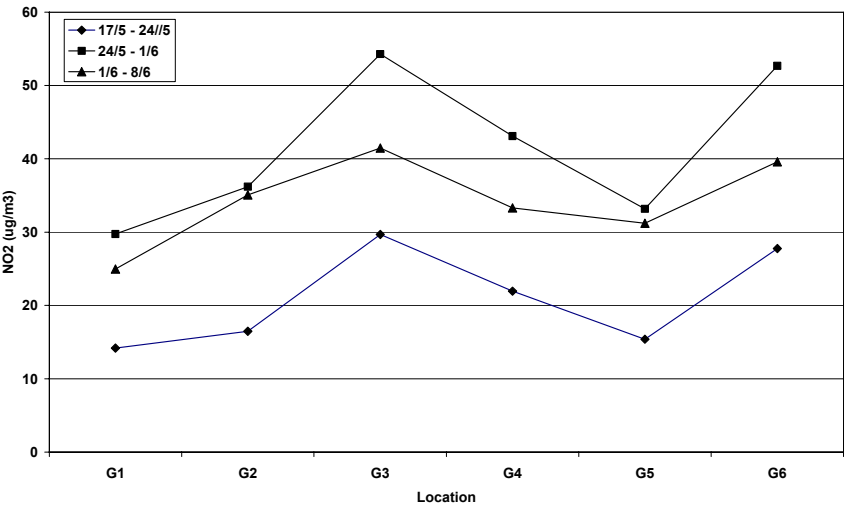

Figure 7: Weekly average NO_2 concentrations measured by diffusive samplers at six locations.

The highest excess concentration for NO and NO_2 compared to 44R701 is measured at location G6. This is possibly due to the high amount of bus traffic. The effect is more apparent for NO supporting this assumption since NOx is mainly emitted as NO. Most of the buses are not equipped with an after treatment system for NOx reduction. Insufficient data are available for location

G3. At location G2 higher concentrations are measured compared to station 44R701. At location G4, also higher concentrations for NO and NO_2 are measured.

The results of the weekly average NO_2 concentrations measured at all six locations during 3 weeks are shown in Figure 7. The same trend was found for different weeks. The lowest concentration was measured at the background location G1. Highest NO_2 concentrations are measured at G6 and G3. In the case of G6 this corresponds to the observations with the NO_x monitor (see Figure 6). For G3 insufficient data are available to compare with.

4 Conclusions

Results from a measurement campaign in the city of Ghent are presented. PM_{10} mass concentrations, NO, NO_2 and black carbon are measured.

At the background location, lowest concentrations were measured for all parameters. Differences in PM_{10} and NO_2 were observed between the different locations. It seems that NO_2 is more sensitive to traffic exposure than PM_{10}. At the bus location, highest NO and NO_2 values were measured. Highest concentrations of PM_{10} and black carbon are measured at the ring location. However some trends could not be explained.

The data presented here are part of a lager study funded by the city of Ghent. These data are used for model validation of the current situation.

Acknowledgements

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