Summary

High air pollution with fine particles mainly occurring during winter time high pressure conditions gave reason to discuss measures which would result in a decrease of fine particle emissions. Road traffic is an important source of fine particle emissions with the size spectrum of these particulate air pollutants ranging from a few nanometres up to 10 µm. Depending on their size nucleation particles, soot aerosols as well as abrasion and resuspension particles are differentiated. All these particles, particularly the soot aerosols, are known to be dangerous to human health. Today's available technology makes it possible by using appropriate particle filter systems (PFS) to practically eliminate emissions of soot aerosols (diameter of 20 to 300 nm) which are predominantly caused by diesel vehicles.

The objective of the present study was to investigate the effects which would result concerning the air quality at the kerbside of a highly frequented urban road, if all diesel vehicles would be equipped with particle filters. For this purpose a three-week field campaign with simultaneous measurement at a site with heavy traffic and an urban background site was carried out in June and July 2006. The traffic-related site is represented by the Schimmel-strasse, a two-lane one way street with a traffic frequency of around 25'000 vehicles per day. Traffic is regulated by light signals. The measuring station of the National Air Pollution Monitoring Network (NABEL) at the Zeughaushof served as an urban background site. At both sites, the particulate air pollutants (PM10, particle number and size distribution) were measured. In addition gaseous pollutants such as nitrogen oxides, ozone, carbon monoxide and carbon dioxide were included in the measuring programme.

The results showed that regarding particle number and volume as well as NO_x values at least twice as high were registered at site Schimmelstrasse compared with the site Zeughaushof. However, PM10 concentrations were only about 25 % higher at the roadside than at the background site. The difference between the simultaneously measured concentration value at the traffic-related and the background station represents the pollutant concentration emitted by the traffic. From this traffic contribution emission factors for light-duty vehicles (LDV) and heavy-duty vehicles (HDV) were computed. On the basis of engine test stand results, the emissions of LDVs could be proportioned according to the contributions of petrol and diesel cars.

The effects of the emissions of these three vehicle categories on the exposure at roadside were determined on the basis of these results. Afterwards various scenario calculations were performed. Particularly taken into account were the two scenarios based on all HDVs or all LDVs with diesel engines being equipped with particle filter systems certified according to VERT (assuming a filter efficiency of 99 %). The installation of particle filters on all HDVs would result in a reduction of the overall soot particle number emission by 75 to 80 %, whereas the potential of the filter system of the diesel LDVs would amount to 15 %. On the other hand, the potential of reducing PM10 mass concentration would be considerably lower with about 20 % for HDVs, because less than half of the PM10 emissions originate from the exhaust. If all diesel vehicles without exception were equipped with a PFS, the traffic contribution to the number of soot particles could be reduced by about 95 %, the contribution to PM10 by approximately 35 %. This would have clearly perceptible effects on air quality at kerbside of an urban main road in a highly populated zone.

THE BENEFIT OF PARTICLE FILTER SYSTEMS FOR IMPROVING KERBSIDE AIR QUALITY

David Imhof, Andreas Mayer (TTM)

INTRODUCTION

High air pollution with fine particles mainly occurring during winter time high pressure conditions gave reason to discuss measures which would result in a decrease of fine particle emissions. Road traffic is an important source of fine particle emissions with the size spectrum of these particulate air pollutants ranging from a few nanometres up to 10 μm. Depending on their size nucleation particles, soot aerosols as well as abrasion and resuspension particles are differentiated. All these particles, particularly the soot aerosols, are known to be dangerous to human health. Today's available technology makes it possible by using appropriate particle filter systems (PFS) to practically eliminate emissions of soot aerosols (diameter of 20 to 300 nm) which are predominantly caused by diesel vehicles.

OBJECTIVE

The objective of this study was to investigate the effects which would result concerning the air quality at the kerbside of a highly frequented urban road, if all diesel vehicles would be equipped with diesel particle filters (DPF).

EXPERIMENTAL

A three-week field campaign with simultaneous measurement at a site with heavy traffic and an urban background site was carried out in the city of Zürich in June and July 2006 (Figure 1). The traffic-related site is represented by the Schimmelstrasse, a two-lane one way street with a traffic frequency of around 25'000 vehicles per day. Traffic is regulated by light signals (Figure 2). The measuring station of the National Air Pollution Monitoring Network (NABEL) at the Zeughaushof served as an urban background site. At both sites, the particulate air pollutants (PM10, particle number and size distribution) were measured. In addition gaseous pollutants such as nitrogen oxides, ozone, carbon monoxide and carbon dioxide were included in the measuring programme.

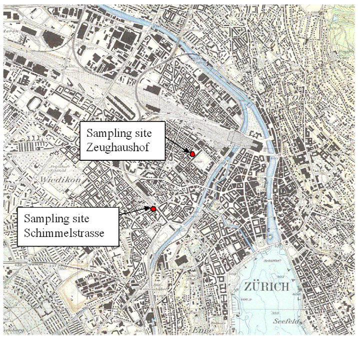

Figure 1. Sampling sites in the city of Zürich.

Figure 2. Traffic situation at site Schimmelstrasse.

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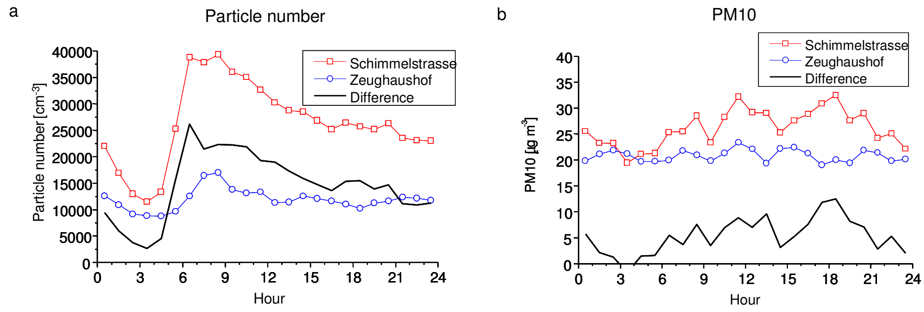

Figure 3. Average diurnal variation of the total particle number concentration (a) and PM10 (b) at the kerbside (Schimmelstrasse) and the background monitoring station (Zeughaushof) in Zürich.

RESULTS

The results showed that regarding particle number (as well as particle volume and NO_x which are not shown here) values at least twice as high were registered at site Schimmelstrasse compared with the site Zeughaushof (Figure 3a). However, PM10 concentrations were only about 25 % higher at the roadside than at the background site (Figure 3b). The difference between the simultaneously measured concentration value at the traffic-related and the background station represents the pollutant concentration emitted by the traffic. From this traffic contribution emission factors for light-duty vehicles (LDV) and heavy-duty vehicles (HDV) were computed. On the basis of engine test stand results, the emissions of LDVs could be proportioned according to the contributions of petrol and diesel cars (Mohr et al. 2006; ACEA, 2002).

The effects of the emissions of these three vehicle categories on the exposure at roadside were determined on the basis of these results. Afterwards various scenario calculations were performed:

- Scenario A: All HDV are equipped with a PFS (filter efficiency of 99 %), no PFS for LDVs.
- Scenario B: All LDV with diesel engines are equipped with a PFS (filter efficiency of 99%), no PFS for HDVs.
- Scenario C: All vehicles with diesel engines (LDV and HDV) are equipped with a PFS.

Based on the emission factors and the number of each vehicle category multiplied by a factor defining the filter efficiency the total emission of the vehicles was computed. In Figure 4, the calculated average diurnal variation of the traffic contribution i.e. the expected concentration difference between the sites Schimmelstrasse and Zeughaushof is depicted for the three scenarios.

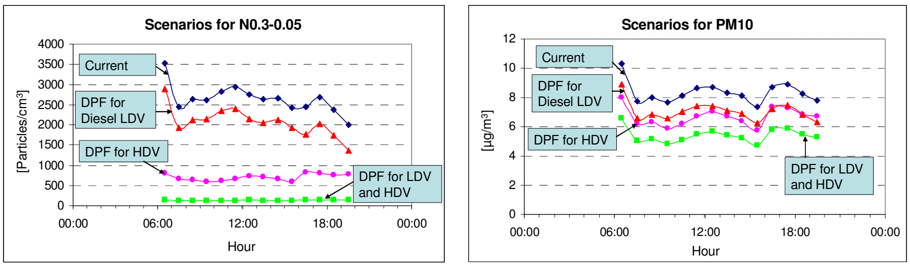

Figure 4. Average diurnal variation of particle number (N0.3-0.05: size range 50 - 300 nm, i.e. mainly soot particles) and PM10 of the traffic contribution at site Schimmelstrasse under application of the three scenarios.

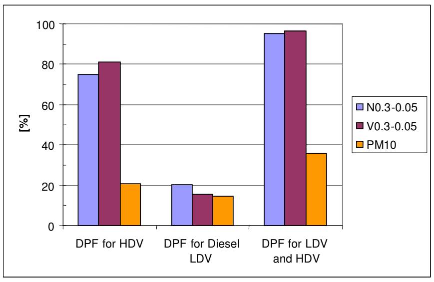

Figure 5. Expected percentage reduction of pollutant concentration emitted by traffic using PFS with a filter efficiency of 99%. V0.3-0.05 is the particle volume in the size range between 50 and 300 nm.

The installation of particle filters on all HDVs would result in a reduction of the overall soot particle number emission by 75 to 80 %, whereas the potential of the filter system of the diesel LDVs would amount to 15 % (Figure 5). On the other hand, the potential of reducing PM10 mass concentration would be considerably lower with about 20 % for HDVs, because less than half of the PM10 emissions originate from the exhaust. If all diesel vehicles without exception were equipped with a PFS, the traffic contribution to the number of soot particles could be reduced by about 95 %, the contribution to PM10 by approximately 35 %. This would have clearly perceptible effects on air quality at kerbside of an urban main road in a highly populated zone. More scenarios are discussed in the project report (Imhof, 2007).

REFERENCES

ACEA, 2002. ACEA Programme on emissions of fine particles from passenger cars [2]. ACEA Report: Brüssel, Belgien.
Imhof, D., 2007. Nanopartikel am Strassenrand. Das Potential des Partikelfilters am Beispiel einer dicht befahrenen Strasse. Project report, Zürich, 1-63. Downloadable on the website of AKPF, Publications: http://www.akpf.org/pub/2007_imhof.pdf
Mohr, M., Forss, A.-M., Lehmann, U., 2006. Particle emissions from diesel passenger cars equipped with a particle trap in comparison to other technologies. Environmental Science and Technology 40, 2375-2383.