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MONITORING OF PARTICULATE MATTER IN A RESIDENTIAL AREA

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ABSTRACT

In this pilot study, a fine dust monitoring network has been installed in the city of Nijmegen. Aim of the pilot study is to determine the contribution of local sources, such as traffic and industry, to ambient particulate matter concentrations. Seven Osiris dust monitors were used measuring hourly mean PM2.5 and PM10, simultaneously. Based on this information, effective local and regional dust reduction measures can be identified. The municipality of Nijmegen will use the results of the pilot study for future air quality monitoring strategy to comply with the European air quality requirements for PM10.

Key Words: Air Quality, Suspended Particulate Matter, Monitoring Network, Contribution of Local Sources

1. INTRODUCTION

In the Netherlands, air quality is determined by a limited number of monitoring stations in the National air quality monitoring network, and additional calculations with air quality models. According to these model calculations, the European air quality requirements for PM10 are exceeded in many locations in urban areas. As a result, spatial planning of new houses or schools near PM10 sources are blocked. However, in some situations, for several reasons, the results of the modeling might not be accurate enough for describing the local conditions. Models in the Netherlands are accepted to be adequate for screening of potential exceedance situations and large scale, time trend monitoring, but are probably not always accurate enough for determination of the occurring local ambient PM10 concentrations. Also the contribution of local sources to local ambient concentrations relative to background concentrations might be different from the modeled situation. Therefore, the municipalities need to get better insight in the contributions of local sources to ambient PM10 concentrations, next to model calculations.

2. EXPERIMENTAL SET-UP

Nijmegen is a city with approximately 160.000 inhabitants, located in the east of the Netherlands, at the border with Germany. Just like most of the country, the area has a high population density. The city territory is rather flat, with the river Waal (Rhine) in the north and some slight hills in the southeast. The river Waal has a lot of shipping. The industrial area is located in the northwest of the city center, with a wide variety of industrial activities, like a power plant, metal handling, iron foundry, waste handling and incineration, and food industries. During two months, seven Osiris dust monitors were installed at various locations around the industrial area at the western part of the city, and in the city centre near a main traffic artery and in a residential area in the city center (figure 1). Local meteorological information, necessary for interpretation of the monitoring results, were obtained from the nearby meteorological station. The monitoring locations can be characterized according EU-definitions as presented in table 1.

Table 1. Characterisation of monitoring locations according EU-definitions.

Monitoring station	**Area character**	**Sources**	**Sampling height (m)**
1	Urban	Street	2.5
2	Urban	Background	2.5
3	Urban	Industry	3.5
4	Rural	Industry	2
5	Rural	Industry	2.5
6	Urban	Industry/street	3
7	Urban	Background	2.5
M	Rural (meteorological station)	-	

Figure 1. Lay-out of the dust monitoring locations 1 to 7 and Meteorological Station

The most important requirements of a PM monitor to answer the questions of this project are: high time resolution of at least one hour, distinction of the size fractions PM2.5 and PM10 and on-line availability of the dust concentration data. Particle size helps to reveal the character of the dust source: particles < 2.5 µm are mainly emitted by chemical sources (like combustion) whereas particles from 2.5 µm to 10 µm are mainly of a mechanical nature (resuspension by traffic, handling a dry bulk materials, wind erosion).

The Osiris dust sampler fitted our purpose. The Osiris operates on the principal of light diffraction and has a virtually constant response, irrespective of the colour of the particles. This small sampler (0.2 m x 0.2 m x 0.5 m) gives a continuous and simultaneous indication of the PM1, PM2.5, PM10 and TSP mass fractions. Another reason why the Osiris sampler was chosen, is that it has low demands on the receptor site. Due to its small size and little weight, it can be easily installed and only requires a low power supply. The Osiris dust monitor is compared to the European reference method according EN12341. The data were collected at the office by mobile phone connections to the samplers.

The data analysis was focused on the size fractions PM2.5 and PM10, as these are most relevant from the point of view of environmental management. Detailed data analysis was carried out by intercomparison of the results of the monitors, as they were located in different wind directions, including local meteorological data.

3. RESULTS

Concentration trend in time

Figure 2 shows an example of the trend in time of PM2.5 and PM10 at one location.

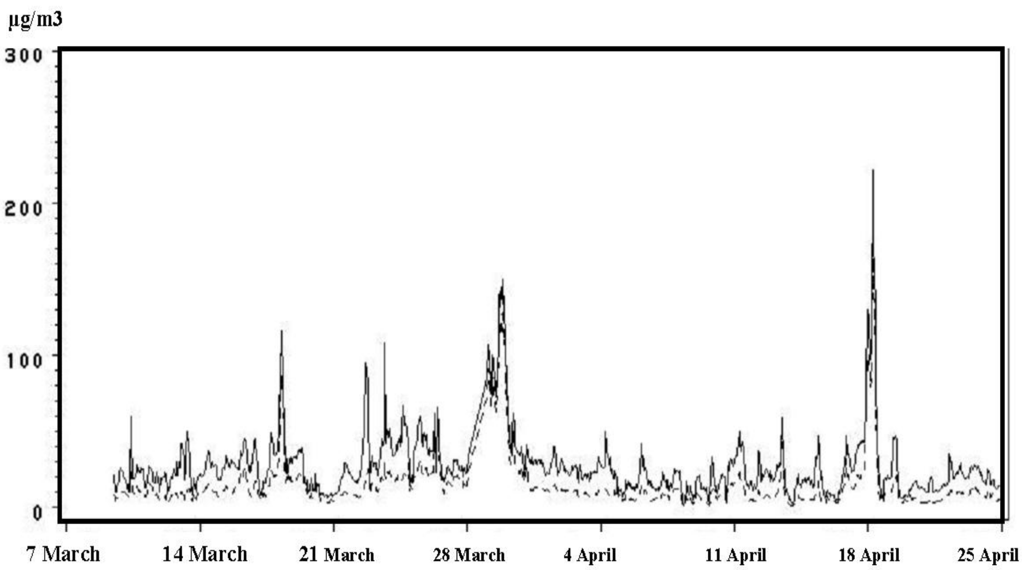

Figure 2. Trend in time of PM2.5 (----) and PM10 (___) at location 4

Highest concentrations were measured on March 29th and April 18th. As PM10 and PM2.5 are almost the same, it shows that it mainly consists of PM2.5. The same peaks occurred at the other 6 monitoring stations. The peak concentrations at March 29th were caused by the traditional Eastern fires in the eastern parts of the Netherlands and in Germany. The reason for the high concentrations on April 18th could not be identified.

Determination of local source contributions

When local sources contribute to the dust measurements, upwind and downwind concentrations will differ. This results in a low correlation between two monitoring sites. Table 2 shows the correlation coefficients between the monitoring locations for PM2.5 and for the coarse fraction of PM10, expressed as PM(2.5-10).

Table 2a. Correlation coefficients between the measuring locations for PM2.5

Location	**1**	**2**	**3**	**4**	**5**	**6**	**7**
1	1	0.94	0.83	0.91	0.91	0.90	0.93
2		1	0.95	0.99	0.96	0.99	0.99
3			1	0.93	0.90	0.88	0.91
4				1	0.95	0.97	0.98
5					1	0,95	0.97
6						1	0.98
7							1

Table 2b. Correlation coefficients between the measuring locations for PM(2.5-10).

Location	**1**	**2**	**3**	**4**	**5**	**6**	**7**
1	1	0.86	0.64	0.46	0.26	0.46	0.60
2		1	0.75	0.52	0.23	0.63	0.65
3			1	0.53	0.42	0.51	0.56
4				1	0.72	0.75	0.79
5					1	0.79	0.74
6						1	0.83
7							1

The correlation coefficients for PM2.5 are quite high. This indicates, that there is a low contribution from specific local sources and it consists mainly of background dust or general local sources. For PM(2.5-10), the correlation coefficients are much lower. So, the contribution of specific local sources mainly consists of the coarse part of PM10. This reveals, that mostly mechanical processes emit dust, such as windblown dust, resuspension by traffic and handling of dry bulk goods.

More detailed information is obtained, when two locations are compared for different wind directions. The scatterplots in Figure 3a and 3b show the correlation between the industrial monitoring stations north (location 4) and south (location 6) of the industrial area.

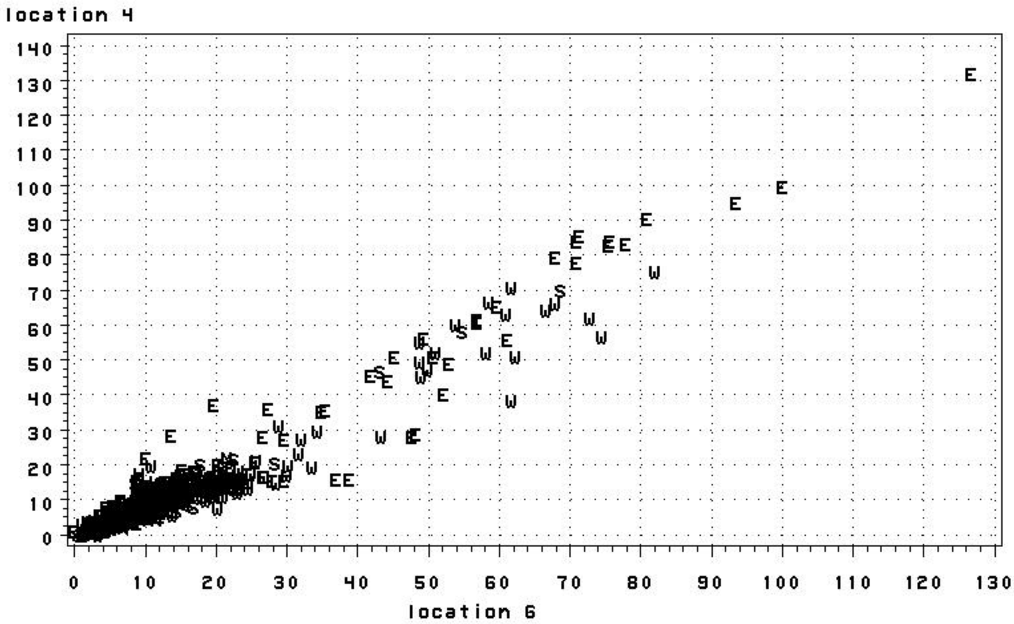

Figure 3a. Comparison of PM2.5 (µg/m³) for locations 4 and 6 for wind directions North (N), East (E), South (S) and West (W).

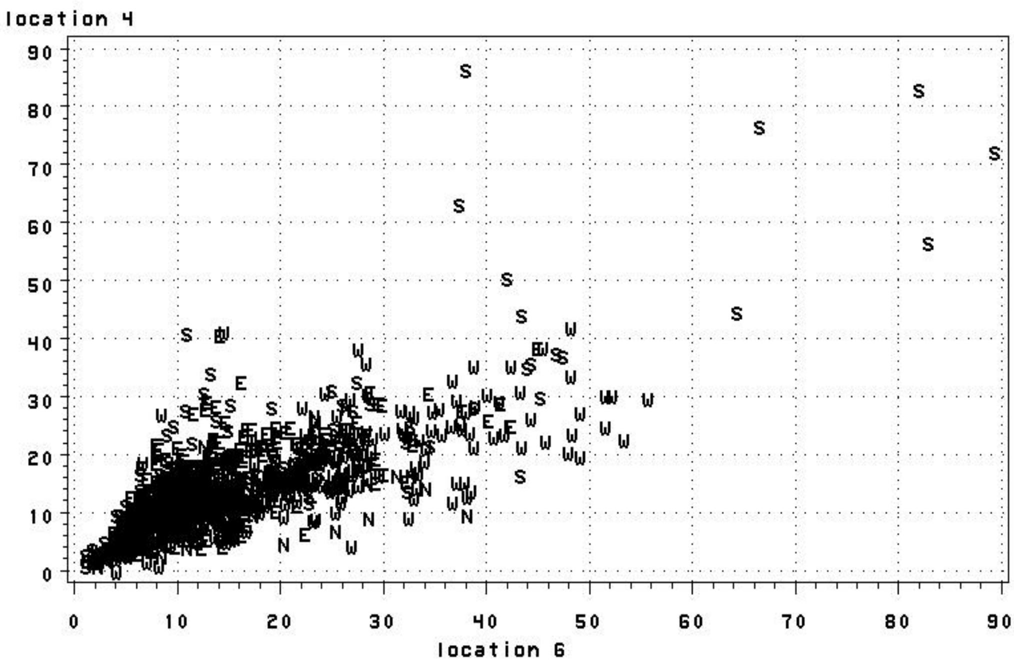

Figure 3b. Comparison of PM(2.5-10) (µg/m³) for locations 4 and 6 for wind directions North (N), East (E), South (S) and West (W).

As was expected, the differences between locations 4 and 6 are small for PM2.5, because ambient PM2.5 levels are mainly determined by large scale background concentrations. For the coarse fraction PM(2.5-10), the concentrations at location 4 are higher with southern winds, whereas location 6 is higher with northern and western winds. This shows a contribution of the industrial area situated in between locations 4 and 6.

Daily concentration pattern

Figure 4 shows the mean daily variation of PM10 and PM2.5 during this two-month monitoring campaign.

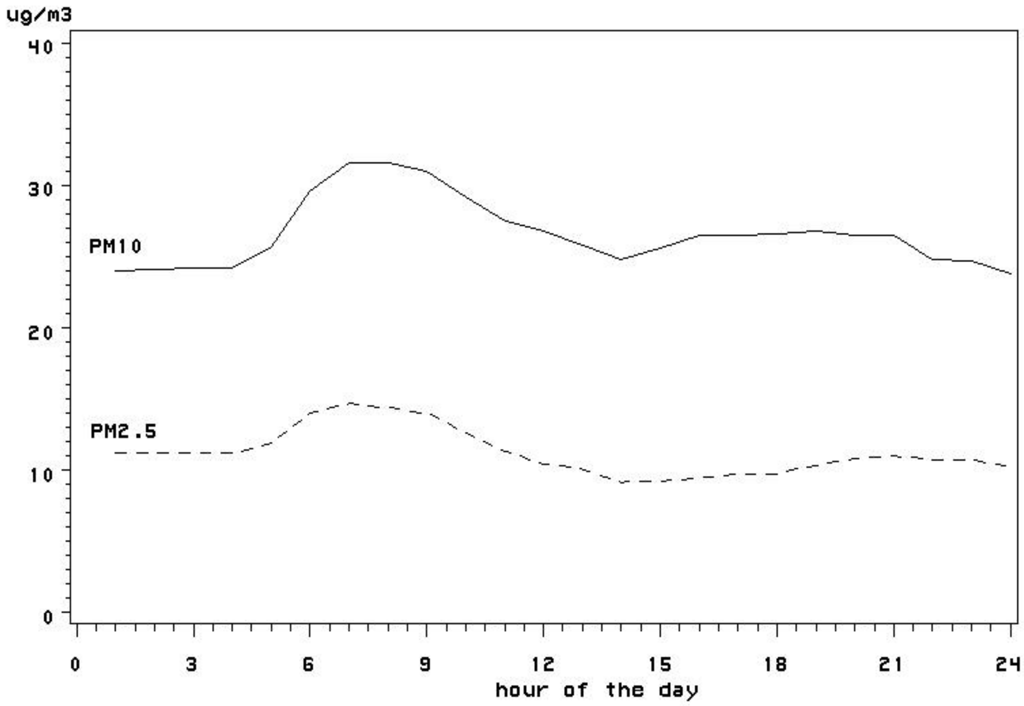

Figure 4. Mean daily variation of PM10 and PM2.5 at location 6.

An increase of PM10 and PM2.5 is observed between 6:00 and 9:00 o'clock. This indicates a contribution of the traffic during rush hours. The same pattern was found at all locations. So, the contribution is probably coming from the whole industrial and residential area.

4. CONCLUSIONS

The dust monitoring network showed a high similarity between the seven measuring locations, especially for PM2.5. For the coarse part of PM10 (PM2.5-10)), local contributions could be detected, caused mainly by mechanical activities at the industrial area. The increase of PM10 and PM2.5 at all locations during rush hours indicates a contribution of traffic from the whole industrial and residential area.

The results of this two-month pilot study show that the contribution of local sources to ambient PM10 concentrations can be determined. This provides a useful tool for ambient air quality management to local environmental authorities.